Industrial QUALITY CONTROL

JULY, 1951

VOL. VIII, NO. 1

ASQC Booth—Fifth National Convention

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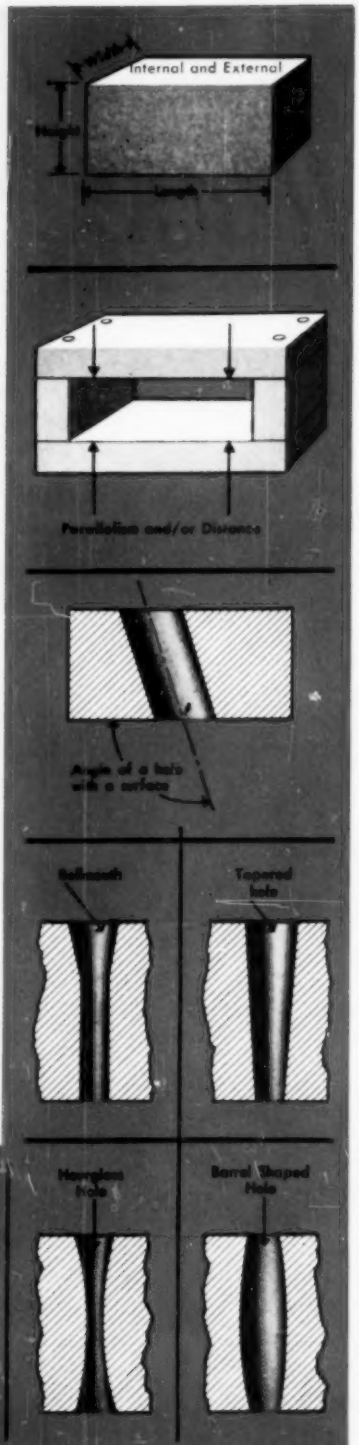

SPECIAL TEN-DAY COURSE IN SERVOMECHANISMS

The theory and applications of feedback control systems (servomechanisms), and the broad concept of "system engineering", will be the subject of a special course during Summer Session 1951 at the Massachusetts Institute of Technology, from August 20 to 31.

Plans for the ten-day course were announced by Professor Donald P. Campbell, of the M.I.T. department of electrical engineering. It will include a survey of the theory of feedback systems with emphasis on dynamic operations and system synthesis. Industrial applications of feedback control systems of servomechanisms, in such diverse fields as steel making, printing, petroleum processing, wood working, textile manufacturing, chemical processing, and power distribution will be discussed.

Following morning lectures, demonstrations and laboratory work in afternoons during the course will make use of the student laboratories in the electrical engineering department. Measurement of system and component performances and methods of testing and evaluating process control equipment are to be included in the laboratory program.

The course is intended for engineers with a background in the problems of industrial engineering and production management. It will be open to those who have had no previous acquaintance with the servomechanisms field, though a familiarity with the engineering problems to be discussed will be helpful.

The course in feedback control systems is one of a series of special summer activities planned during 1951, under the general direction of Professor Walter H. Gale, director of the M.I.T. Summer Session. All are designed to make M.I.T.'s technical and educational facilities available to those who cannot participate in the regular academic program.

Participants may reserve rooms in M.I.T.'s new dormitory, the Everett Moore Baker House, overlooking the Charles River Basin and Boston. All facilities and privileges of the Institute will be open to them.

Further information on this and other special summer activities may be obtained from Professor Gale, Director of Summer Session, Room 3-107, Massachusetts Institute of Technology, Cambridge 39, Mass.

Industrial Quality Control

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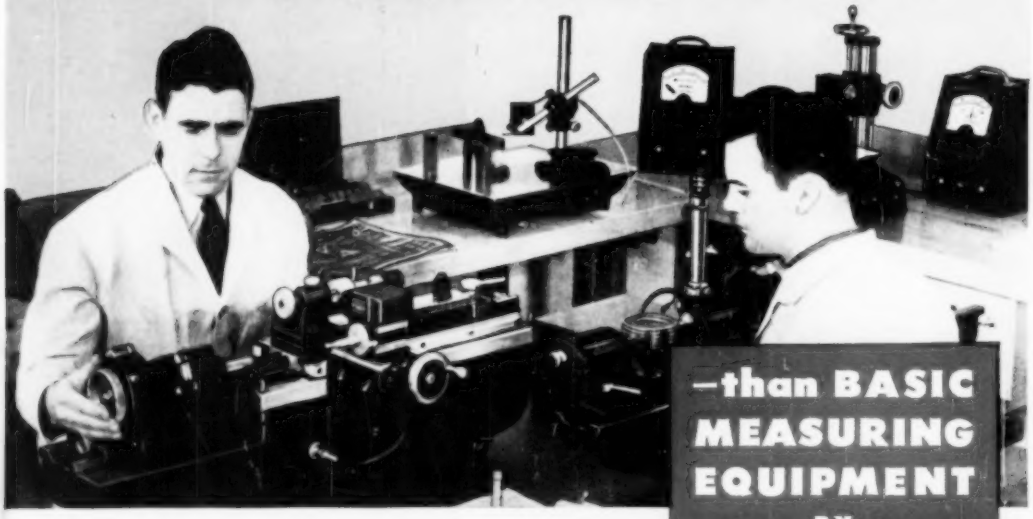

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Quality Control—Today's Foundation for Tomorrow's Reputation*

MARTIN A. BRUMBAUGH

Bristol Laboratories

THE slogan of this Convention is more than a few catch words put together for publicity purposes. It is the creed of the men and women who have staked their industrial reputations on the soundness and importance of the principles of Quality Control. The word "foundation" is used in its most common sense as "That upon which anything stands and by which it is supported". The word "reputation" is used in the sense of the character attributed to an industrial concern by the public. What follows, then, is a discussion of Quality Control as a support of industrial character.

INDUSTRIAL CHARACTER

Industrial character is a result of the net and balanced impact of a variety of forces both internal and external upon an industrial concern. The evaluation of that character is largely external and entirely objective. The building of that character is entirely internal and unfortunately in many concerns only implied.

The elements of this evaluation are worth listing. Consumers judge a concern on product quality which may feature durability, functional precision, interchangeability, or low operating cost, and particularly in a household article or wearing apparel, comfort, style, appearance, or price. A concern is also judged by its advertising. This applies all the way from local newspaper to national magazine, including billboard or other media. Millions of persons who have never used or may never have seen the products of a concern have very definite ideas of the character of that concern gained solely from its advertising. A company is judged by the utterances and actions of its management personnel. This subject is too big for discussion here. Suffice it to say that industrial reputations might be improved in some cases if corporate officers understood more clearly that along with the perquisites of office go responsibilities which essentially make them captives of public opinion. A concern is judged by its sales policies as expressed by its field organization. It is judged by its labor relations. In fact, every contact with the public is part of the evaluation of the industrial character of a concern.

All of this, however, is effect and as previously stated is external. Let us turn now to the cause, the internal building of industrial character. While poor public relations through misguided advertising, sales, management, or labor relations can assassinate industrial character in spite of product excellence, nothing that can be done by advertising, by sales, by management, or by personnel policies will permanently offset *failure* to market a product which has public acceptance. Consequently, the sequel will deal with the relation of the principles of quality control to the manufacture of acceptable product.

QUALITY CONTROL AS A SUPPORT OF INDUSTRIAL CHARACTER

Earlier, quality control was called a support of industrial character. The nature of that support in a general sense is well known to all of us, but a transfer from the general to the specific brings to light the fact that there is a divergence of point of view among quality control men concerning the nature of the support to industrial character provided by quality control. It is the point of view of this paper that such support should be provided at three levels and that the development of those three levels should be simultaneous in the planning of the quality control manager but sequential in their maturity in his plant. The three levels are:

1. The installation of procedures which will reduce inspection costs, routinize inspection operation, introduce quality uniformity into incoming material and finished products, provide information for production which can be used to improve quality, thus reducing reoperation and scrap. The transfer from product control to process control follows with control chart management of processes, both fabrication and assembly. This can be called "bread and butter" control because through these activities immediate savings can be shown to the credit of the quality control department. For better or worse, evidence of such savings is indispensable to the continued existence of the department in the eyes of cost conscious management.
2. The core of this level is process investigation. It is becoming in-

*Shewhart Medalist Address, Fifth National Convention, ASQC, Cleveland, Ohio, May 23, 1951.

creasingly apparent that many of the engineering problems arising out of control chart process management are extremely baffling until statistical design and analysis are introduced. The effective team is the trained engineer and the statistical approach. This may or may not be a one man team according to the talent available in an individual plant. Process investigation connects directly with development and piloting laboratories in chemical type industries, and increasingly with metallurgical laboratories, and design and development departments of mechanical and electrical industries. The area which is just beginning to open up is statistical design and analysis of research experimentation.

The dollar position of this level is exactly the opposite of the first level. The return is remote but the benefit is immediate. A few managements, wiser than most, have seen the advantage of the longer range point of view and have encouraged their quality control managers to develop this second level. Here is the answer to a question which has never quite been settled. Some reputable quality control men have stated that quality control work is 10% statistics and 90% engineering and plant knowledge. These percentages might be approximately correct in quality control work at the first level, but they are not pertinent at the second level. A fairly distinct outline of the place of the statistician emerges as emphasis shifts toward quality control at the second level. His techniques and his point of view become indispensable.

3. The third level of quality control work is the introduction, fostering, and development of statistical thinking in a plant in all phases of operations. This is primarily a selling job, which requires that whole segments of supervisory personnel be indoctrinated with the ideas of variability, probability, risks of decision, significance of differences of averages and other measures, and similar aids to clarity of thinking. The greater the number of people in a plant, from executives to foremen and operators, who acquire these aids to clear thinking, the greater the opportunity for quality control growth and hence for support of industrial character.

At the risk of being repetitious, it should be emphasized that every quality control manager should put first things first. The installation of "bread and butter" type controls must come first. Only when these are sufficiently complete and sufficiently routinized can he give attention to the process investigation type of control operation. Many of our quality control installations are entirely confined to the first type of operation because the task of establishing routine controls is not easy. Each of us could prepare his own list of difficulties encountered including on most lists unsympathetic supervisors, hostile foremen, and apathetic management. None the less, the first step must be to surmount these obstacles and win through to a set of appropriate routine controls which can be evaluated in terms of lower cost and quality improvement.

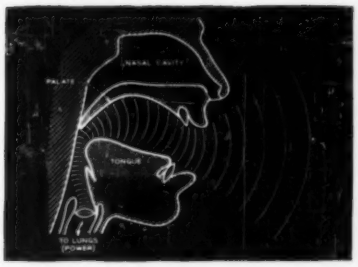
Subsequently, the investigational type of control work can be developed, but comparatively few of our installations have done so at this time. This in itself is clear evidence of the unlimited future of quality control. However, there are two types of errors that can be limiting factors. Some quality control managers do not include process investigation in their departmental planning, and to some extent at least this is the result of failure to comprehend the importance of the statistical approach to the solution of problems. The second error is in some cases chargeable to statisticians who, having taken charge of a quality control installation, have concentrated on the process investigation type of work without first building a foundation of routine controls for their edifice. Both of these errors constitute limiting factors on an otherwise unlimited future for quality control work.

The third function of the quality control manager, selling quality control thinking, should be carried on jointly with the first two functions. The greater the number of people in a plant who learn to use the language of quality control and think in terms of numerical data, averages, variability, homogeneity, random sampling, significance testing, etc., the greater the rate of spread of the quality control idea in the plant.

A statement made earlier will perhaps have more specific meaning if repeated at this point. My proposal was to discuss quality control as a support of industrial character. Emphasis is on the *supporting* role of quality control. It thus becomes another service function on the industrial organization chart. As such the burden is on the quality control manager to demonstrate his worth to his company. Specifically the case is this: as companies have grown in size and products have grown in complexity, the auxiliary functions have likewise grown in number. Included in these are engineering, accounting, cost accounting, budgeting, planning, scheduling, routing, product engineering, time and motion study, methods in general, personnel, safety, etc., and now quality control. In spite of this multiplication of functions the primary objective of management is to make goods and sell goods. Anything that increases the cost of manufacture, increases the difficulty of selling. Therefore, management is entitled to ask the quality control man either of two questions acording to the pertinent circumstances: (1) Can you reduce costs by more than the expense of your department? or (2) Can you improve quality to a point where our product can command a higher price in competitive markets? Unless the quality control manager can demonstrate fairly concretely how he proposes to achieve a positive answer to one or both of these questions, he is not entitled to consideration from management.

This is the background which leads me to take issue mildly with those who promote the idea that a quality control man should always see to it that others get the credit for improvements. There is a middle ground on this matter, and the quality control manager will do well to put in the hands of someone holding the purse strings an unbiased estimate of the worth of his department to the company. He is in a peculiarly good position to evaluate his work because he is dealing directly with the production process and is creating the records from which such evaluation can be made.

From this concept of the quality control function emerges support for industrial character which is tangible, measurable, and salable. Companies that operate with the support of a well administered quality control function have a sound foundation for tomorrow's reputation.



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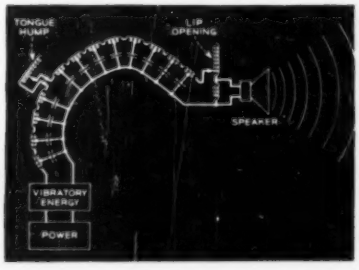

The machine at the left is saying "Ah!" It's the new electrical vocal system developed at Bell Laboratories. Top sketch shows human vocal system also saying "Ah!" The electrical model is sketched below it. Energy source at bottom of "tract" can emit a buzz sound, like vocal cord tone, or the hiss sound of a whisper.

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This is another step in the research at Bell Telephone Laboratories which pioneered the exact knowledge of speech. Past work in the field is important in today's fine telephone service. A still deeper understanding of speech is essential in planning for tomorrow.

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Some Antecedents of Quality Control*

EDWARD C. MOLINA

Bell Telephone Laboratories

IN his recent work on "Statistical Quality Control" E. L. Grant quotes L. T. Rader as follows:

> "There are many difficulties and troubles with which a factory management has to contend—dies which wear; bearings that get loose; stock which is undersize, oversize, or dirty; loose fixtures; careless, tired, or untrained employees. For these reasons it would seem that there is no mathematical method which takes into account all these factors. However, there is a kind of mathematics which is applicable in just such conditions, and that is the mathematics of probability."

In other words, the Mathematical Theory of Probability underlies the technique of Quality Control. This being so, I shall here present for consideration some applications of probability theory made within the Bell Telephone System during two decades anteceding the birth of Quality Control in 1924.

BIRTH OF PROBABILITY THEORY

In spite of my advanced age I was not present at the first conference called to consider the application of probability theory to practical problems. That conference was held in Paris in 1654.

History informs us that a notorious gambler, the Chevalier de Méré felt that his scheme for collecting nickels from the public was not enriching him to the extent anticipated. Therefore at the 1654 conference he submitted to Blaise Pascal a certain dice problem. Pascal, one of the two greatest mathematicians of the day, attacked the problem with avidity. He corresponded with the other outstanding mathematician as to the most appropriate form for the solution of the problem and, thus, the Mathematical Theory of Probability was born. The other great mathematician was Fermat.

Since Méré gave the impetus to the pioneer work of Pascal and Fermat a few words concerning him are in order. In the Life of Pascal by Morris Bishop we read:

> "The Chevalier de Méré was remarkable both as individual and as type. A soldier with a brilliant record, a linguist, author (after the time of which we treat) of several reflective volumes on life's conduct, a society wit much sought by hostesses, hero of several elegant liaisons, he was the summary of worldly civility, the perfect courtier. 'The professional bel esprit' says Père Rapin, contemptuously. He made a precarious living at cards and dice, wagering according to a private calculus of probabilities. He was the inevitable guest in the great chateaux, paying for his lodging with geniality and social charm."

But I shall not describe the particular dice problem which worried Méré. Today gambling is not a legitimate industry and I shall not run the risk of bringing down on our heads a congressional investigation.

Leaving the Paris of 1654 behind, let us run up to Boston where the research department of the A.T.&T. Co. was located prior to the reorganization of 1907.

In the Boston archives there is a memorandum entitled: "Application of the Theory of Probability to Traffic Problems." This memorandum, dated October 22, 1903, was written by the late Malcolm C. Rorty, at one time Vice President of the American Founders Corporation and President of the American Statistical Association. This Rorty memorandum set the stage for the early work done within the Bell System on applications of probability theory to practical problems. Having set the stage, Rorty transferred from the traffic department in Boston to the traffic department of the Pittsburgh Telephone Company and left us to carry on. I am the happy owner of a copy of the original Rorty memorandum.

THE DIAL TELEPHONE SYSTEM

The problem to which probability theory was *first* applied by the Bell System engineers was that of variations in traffic density resulting from the haphazard incidence of calls from subscribers; a problem fundamental in the design of dialing systems, systems involving the investment of *millions* of dollars. This first application was made in the fall of 1905 and led to a revolution in the design of switching systems. Prior to that time the selecting elements of an automatic telephone exchange were designed for a capacity of 100 lines; a capacity dictated by the fact that mankind having been endowed with ten fingers it seemed that the selectors should operate in accordance with the decimal system of enumeration.

Probability theory found that a given percentage deviation above the average traffic carried by a large group of trunks was much less likely than the same percentage deviation for a small group. The theory therefore issued an order to the effect that switches giving access to trunks and lines in large groups be installed. This dictum was carried out by the design and installation of the 500 lines capacity "panel" switch. Panel exchanges embodying 500 lines capacity switches have been giving subscribers in our larger cities excellent service at a reasonable cost for the last quarter century.

At first it looked as if the dictum of probability theory could not be carried out. Decimally operating switches of the types existing prior to 1905 would not, for mechanical reasons, lend themselves to enlargement. If large switches were to be installed, the subscribers' dial would have to be redesigned to transmit pulses on a non-decimal basis. There were two serious objections to such a redesign of the dial. The first was the difficulty of inducing the public to abandon its ancient and honorable method of counting on its ten fingers. The second difficulty was that, if at any time a switch operative on still another non-decimal basis were to

*A talk to the Metropolitan Section of the American Society for Quality Control at the Essex House, Newark, N. J., on January 17, 1950.

prove more efficient, then another redesign of the dial would be involved.

Fortunately Probability Theory is not the only branch of mathematics available to engineers. The *Theory of Numbers* appeared on the scene and made the following suggestion: "Install a set of registers to take up a decimally dialed number and let a translator change the number so registered into the numerical scale for which the switches are designed." This suggestion was carried out with the result, as previously stated, that for many years our larger cities have been receiving service from telephone exchanges equipped with "panel" selectors. The new Crossbar system also employs translation.

Those who may wish to learn something more about translation, a fundamental invention *dictated* by probability theory but *accomplished* by an application of number theory, will be interested to read the article entitled "Historic Firsts: Translation" which appeared in the November, 1948 issue of the Bell Laboratories Record.

The application of probability theory to dial systems called for some research in pure mathematics. Many years later this research was crystallized into the Poisson Tables now playing their part in the drama of Quality Control. In his paper of 1903 Rorty used for the numerical evaluation of the incomplete binomial summation the familiar Bernoulli-Laplace, Normal or Gaussian integral, as it is variously called. Now this integral is useless for the evaluation of those binomial summations in which dial systems engineers are interested. New formulas of approximation had to be developed; they were published some years later in the June 1913 issue of the American Mathematical Monthly. The limiting form of the formulas turned out to be identical with the Exponential Binomial Limit developed by Poisson in his famous treatise on probabilities of 1837. I have blueprints of the first set of Poisson limit curves used within the Bell System. They are dated July 6, 1908, and thus antedate by more than three decades the publication of the Tables by D. Van Nostrand in 1942.

IRREGULARITIES IN LINES OF PERIODIC STRUCTURE

Another application of Probability Theory to problems confronting the telephone industry was started shortly after the beginning of 1910. This application played an important part in the research and development work preceding the opening of the trans-continental line to San Francisco in 1915.

The problem now under consideration will be more readily understood if we first devote a few minutes to a famous dice problem solved by the exiled French Huguenot De-Moivre in about the year 1711.

Consider three accurately constructed, unbiased dice. If I throw one of them up in the air and let it fall on the table, the face turned up may be any one of its six. Now suppose I throw all three dice simultaneously and that we are interested in the *sum* of the three numbers on the faces turned up. This sum may have the minimum value $3 = 1 + 1 + 1$ or the maximum value $18 = 6 + 6 + 6$, or any intermediate value, for example, 10. Please note, as it is the all-important point for the analogous telephone problem which I shall discuss shortly, that whereas there is only one way of obtaining the sum 3 and only one way for the sum 18, there are 27 ways of setting up the sum 10. Thus, while it is *possible* that the sum may have any value from the lowest 3 to the highest 18, the *probabilities* are in favor of some intermediate value. The point I wish to emphasize would come out more vividly if I were to toss 8 instead of 3 dice. The minimum sum would then be 8 and the maximum 48. Each of these could appear in only one way. But there are 135,954 different ways in which the sum 28 can be constructed by adding eight numbers each of which may have a value from 1 to 6, inclusive.

Now interpret the number turning up on an individual die as an irregularity. Then the dice problem illustrates that it is possible for the *sum* or *cumulative* value of several independent irregularities to have a low or a high value, but that the probabilities are greatly in favor of an intermediate value. If the individual irregularities may take on negative and positive values with equal frequencies, the most probable value for their *sum* is zero.

We are now prepared to consider an important class of telephone problems involving irregularities; the loaded line problem, for example. For those unfamiliar with telephone transmission problems it will suffice to state that a "loaded line" is one in which so-called "loading coils" are inserted into the line at regular intervals and that these coils have the remarkable property of not only increasing the volume of sound received at the distant end of the line but also of greatly improving the articulation of the received sound message.

The coils are assumed to be at exactly equal distances apart and, moreover, their resistance, inductance and other electrical characteristics should be the same for each individual coil. But this ideal situation is out of the question. Variations, or irregularities, will occur. No group of installers can place coils at exactly equal distances apart; no manufacturer can turn out coils which are exactly alike in their characteristics. The telephone engineer was therefore confronted with the problem: What is the probability that the *sum* or *cumulative* value of several independent irregularities will lie within limits such that the gains to be expected from loading will not be materially affected? Theory gave the answer; an answer which set the tolerances for acceptable variations in coil characteristics or inaccuracies in their placement.

CONCLUDING REMARKS

The above brief resumé of some of the early work in applying probability theory to telephone engineering problems justifies the following statement:

Probability theory—given birth by Pascal and Fermat, guided through adolescense by mathematicians such as DeMoivre, the Bernoullis, Bayes and Gauss, brought to manhood by Laplace—is more than a game designed for the intellectual enjoyment of abstract thinkers. It is a valuable tool for the solution of practical problems, transforming the vague indications of common sense into precise rules of action.

Finally, it must not be thought for a moment that the domain of telephony is the only one in which probability theory has been applied. A glance at the volumes of Biometrika, the official journal of the Pearsonian school of statistics, will immediately dispel any such false impression. Being a Bell System telephone engineer, the writer has limited himself to presenting applications of which he has first-hand knowledge and in which it was his privilege to take part.

Operation "Blueprint"—An Editorial

Mason E. Wescott

THE Constitution of the American Society for Quality Control, Article I, Section 1-b.-(1) states that a purpose of this Society shall be "to create, promote, and stimulate interest in the advancement and diffusion of knowledge of the science of quality control and of its application to industrial processes."

Just what *is* the "science of quality control"?

Since its founding in February, 1946, this Society has been literally preoccupied with the business of surviving the inevitable "growing pains" of a new organization. Its officers have been struggling valiantly in an effort just to conduct soundly and efficiently the administrative details of such a rapidly expanding organization. Its journal has been struggling with equal zeal to get itself oriented financially and physically to meet the many challenging needs of our Society for an adequate publication service.

In short, the history of ASQC to date has left little time or inclination for serious thought or concrete expression addressed to the business of spelling out what the #1 objective of the Society really means. True, from time to time our journal has published thought-provoking papers contributing to this general theme:

G. D. Edwards—"The Future of Quality Control", May, 1946;

J. M. Juran—"The Relation of the Quality Function to the Industrial Enterprise", July, 1946;

A. G. Dalton—"The ABC of SQC", January, 1949;

L. E. Simon—"The Advancing Frontier of Quality Control", May, 1949;

W. R. Weaver—"The Place of the American Society in Modern Quality Control", May, 1949;

W. R. Purcell—"The Scope of Quality Control", September, 1949;

M. A. Brumbaugh—"Quality Control—1949 Model", January, 1950.

Nevertheless, the fact remains that with respect to a specific formulation of what the functions of ASQC should be in translating "the science of quality control" into industrial practice *at all levels* we, as a Society, have been pretty largely "playing by ear".

In the recent past a veritable rash of "technical committees" have been formed and/or proposed in an effort to recognize and coordinate special areas of interest within the Society. Without the slightest intention to criticize or discredit this development, its very existence nevertheless poses certain basic questions, viz.

How far should ASQC go in the formation of technical committees?

What are realistic criteria for the formation of a technical committee?

Just how do technical committees fit into the general pattern of the Society's over-all objectives?

Does ASQC *have* a "general pattern of over-all objectives" formulated with sufficient clarity to serve as a reference frame against which to judge the merits of proposals for specific activities?

The spectacle of the recent Convention in Cleveland should have had a sobering effect on everyone sincerely concerned for the future growth and strength of ASQC. As a Society, this Convention was eloquent testimony to the fact that we have "arrived".

Where do we go from here?

Are we to continue trying to be all things to all people?

Have we a definite concept of what "the science of quality control" embraces?

Have we a concrete program to offer industry as the sole society dedicated to "the science of quality control"?

What *is* "the science of quality control" to which ASQC is committed?

The time has come when serious thought must be given, and quickly, to formulating clear-cut answers to these and similar questions lest our Society risk the danger of losing the all important element of surface tension so necessary to give it purposeful and clearly defined direction in its further expansion.

Two papers of fundamental importance in this connection were presented at the Cleveland meetings. One of these, the Shewhart Medalist Address by Martin A. Brumbaugh, appears in this issue. The other, by J. M. Juran, was presented at Period II—Series E under the title "Installing a Quality Control System". This paper, or a revision of it by its author, will be published in a subsequent issue of this journal.

These two papers have many points in common as well as certain fundamental points of divergence, but both are devoted to the theme of developing a clear-cut blueprint of "the science of quality control".

At the meeting of the Editorial Board in Cleveland it was agreed that space should be provided in Vol. VIII of IQC for editorials on the subject initiated by this editorial and also—and more especially—for letters to the editor from our readers. It was further recommended that a session be provided on the program at the 1952 Convention for further discussion and clarification of the direction our Society should move in defining the "science of quality control" and setting a clear-cut course for translating these concepts into industrial practice.

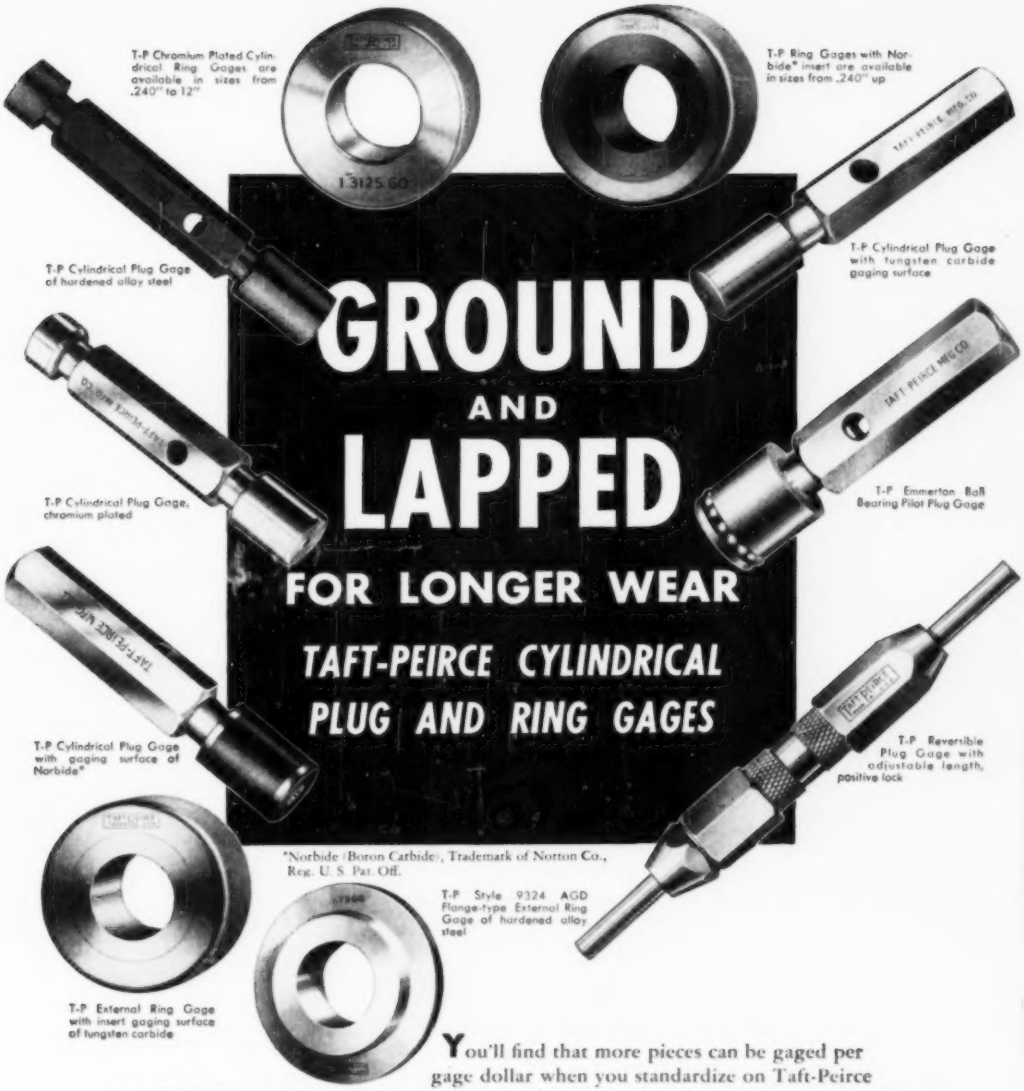
Accordingly, letters from our readers are invited on this subject and will be published in whole or in part as space permits. Only by hammering out on the anvil of friendly and constructive debate the issue of what "quality control" embraces and the functions of ASQC in furthering an understanding and use of it in industry can we hope to meet successfully the challenge of the opportunity that lies before us.

We can't do the job ahead of us effectively if we don't have clearly defined concepts of what that job is.

Do we need a tightening or a relaxation of our specs?

What is a blueprint for modern quality control?

What *is* "the science of quality control"?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Report of Standards Committee, ASQC

Submitted April 6, 1951 to Mr. Wade R. Weaver, President ASQC

Your Standards Committee is pleased to submit herewith the final draft of Standard Definitions and Symbols for Control Charts as given in the accompanying document.

In accordance with a letter of instructions to me dated October 1, 1947 from Mr. George D. Edwards, then President of ASQC, the Standards Committee understands that its duties may be summarized as follows:

"The Standards Committee is authorized to study and select those symbols, concepts, nomenclature, procedures, and other matters which it feels the Society would find advantage in standardizing and to make recommendations to the Board of Directors for such standardization by the Society."

The accompanying proposed standard has had the benefit of wide comments from all Sections of ASQC. As you may recall, a first draft was forwarded to President Wareham on November 28, 1949. This draft was published in the March, 1950 issue of Industrial Quality Control. Subsequently on June 15th a copy was sent to each of the Sections of ASQC inviting comments. Some fifty sets of comments were received, many of them very helpful and constructive. These have been considered in great detail and the attached document represents a final draft which incorporates changes based on the many comments received. This document has received the unanimous approval of the Standards Committee.

Accordingly, the Standards Committee wishes to recommend to the Board of Directors that the attached standard definitions and symbols for control charts be standardized by the American Society for Quality Control.

ASQC STANDARDS COMMITTEE
Irving W. Burr
Eugene L. Grant
Ralph E. Wareham
A. E. R. Westman
Harold F. Dodge, *Chairman*

Proposed

Standard Definitions and Symbols for Control Charts

FINAL DRAFT

TERM	SYMBOL	DEFINITION
1. GENERAL TERMS RELATING TO CONTROL CHARTS		
Unit		One of a number of similar items, objects, individuals, etc.
Variables, Method of		Measurement of quality by the method of variables consists in measuring and recording the numerical magnitude of a quality characteristic for each of the units in the group under consideration. This involves *reading a scale* of some kind.
Attributes, Method of		Measurement of quality by the method of attributes consists in noting the presence or absence of some characteristic (attribute) in each of the units in the group under consideration and counting how many do or do not possess it. Example: Go and Not-Go gaging of a dimension.
Universe or Population		The total collection of units from a common source; the conceptual total collection of units from a process, such as a production process. Also used in the sense of a "universe (or population) of observation." *Note:* "Universe", "population", and "parent distribution" are synonymous terms. Statistical methods are based on the concept of a distribution of an exceedingly large number of observations, termed an infinite universe or population. An individual observation, the X of a sample, etc. may be thought of as one coming from a parent distribution or infinite population of like items.
Sample		A group of units, or portion of material, taken from a larger collection of units, or quantity of material, which serves to provide information that can be used as a basis for judging the quality of the larger quantity, or as a basis for action on the larger quantity or on the production process. Also used in the sense of a "sample of observations."

TERM	SYMBOL	DEFINITION
Sample Size	n	The number of units in a sample. Also used in the sense of the number of observations in a sample.
Assignable Cause		A factor contributing to the variation in quality that it is economically feasible to identify. Assignable causes must be identified and removed to attain statistical control.
Subgroup		One of a series of groups of observations obtained by subdividing a larger group of observations; alternatively, the data obtained from one of a series of samples taken from one or more universes.
Rational Subgroups		Subgroups *within* which variations may for engineering reasons be considered to be due to non-assignable chance causes only, but *between* which there may be variations due to assignable causes whose presence is considered possible. (One of the essential features of the control chart method is to break up inspection data into rational subgroups.)
Statistical Measure		A mathematical function of a set of numbers or observations. Common statistical measures are the arithmetic mean or average, the standard deviation, the range (for variables), and the relative frequency (for attributes).
Control Chart		A graphical chart with upper and lower control limits and plotted values of some statistical measure for a series of samples or subgroups. A central line is shown frequently.
Control Limits		Limits on a control chart which are used as criteria for action or for judging the significance of variations between samples or subgroups.
Central Line		A line on a control chart representing the average or expected value of the statistical measure being plotted.
Control Chart—No standard given		A control chart whose control limits are based on the data of the samples or subgroups for which values are plotted on the chart.
Control Chart—Standard given		A control chart whose control limits are based on adopted standard values of the statistical measure(s) for which values are plotted on the chart.
2. TERMS RELATING TO CONTROL CHARTS FOR VARIABLES		
(a) Statistical Measures		
Observed Value or Observation	X	The measured value of a quality characteristic for an individual unit; specific observed values are designated X_1, X_2, X_3, etc.
Average	$\bar{X}$ (X bar)	The arithmetic mean: the average of a set of n numbers, $X_1, X_2 \ldots\ldots X_n$, is the sum of the numbers divided by n; $\bar{X} = \frac{X_1 + X_2 + \ldots + X_n}{n}$
Standard Deviation	σ (sigma)	The standard deviation of a set of n numbers, $X_1, X_2, \ldots X_n$, is the root-mean-square (r.m.s.) deviation of the numbers from their average: $\sigma = \sqrt{\frac{(X_1-\bar{X})^2 + (X_2-\bar{X})^2 + \ldots + (X_n-\bar{X})^2}{n}}$ or expressed in a form often more convenient for computation purposes: $\sigma = \sqrt{\frac{X_1^2 + X_2^2 + \ldots + X_n^2}{n} - \bar{X}^2}$.
Range	R	The range of a set of n numbers is the difference between

TERM	SYMBOL	DEFINITION
		the largest number and the smallest number. (More precisely: the absolute value of the algebraic difference between the highest and lowest values.) R = (largest number) − (smallest number).
(b) Terms Relating to a Sample (or Subgroup)		
Sample Average	$\bar{X}$ (X bar)	The sum of the observed values in a sample divided by the number of observed values.
Sample Standard Deviation	σ (sigma)	The root-mean-square (r.m.s.) deviation of the observed values of a sample from their average.
Sample Range	R	The difference between the largest observed value and the smallest observed value in a sample.
(c) Other Terms		
Average value of X, σ, or R	$\bar{\bar{X}}$, $\bar{\sigma}$, $\bar{R}$ (X double bar, sigma bar, R bar)	The average of the set of sample values of X, σ or R under consideration. For samples of unequal size, a weighted average is used. These values are used in computing control limits for the case "No Standard Given."
Standard Value of X or σ	X', σ' (X bar prime, sigma prime)	The value of $\bar{X}$ or σ adopted as standard for computing control limits for the case "Standard Given." (These symbols are also used to designate the true or objective value of X or σ of the universe sampled.)
Factor for Central Line—Standard Deviation	c_2	A factor, varying with sample size n, that is equal to the ratio of the expected value of $\bar{\sigma}$ for samples of size n to the σ' of the universe sampled; $c_2 = \bar{\sigma}/\sigma'$. (Published values* are for a Normal universe.)
Factor for Central Line—Range	d_2	A factor, varying with sample size n, that is equal to the ratio of the expected value of R for samples of size n to the σ' of the universe sampled; $d_2 = \bar{R}/\sigma'$. (Published values* are for a Normal universe.)
Standard Deviation of X, σ, or R	$\sigma_{\bar{X}}$ $\sigma_{\bar{\sigma}}$ $\sigma_{\bar{R}}$	The standard deviation of the sampling distribution of $\bar{X}$, $\bar{\sigma}$, or $\bar{R}$.
3. TERMS RELATING TO CONTROL CHARTS FOR ATTRIBUTES		
(a) Statistical Measures		
Relative frequency, proportion	p	The ratio of the number of "events" to the number of "trials" under consideration, where only one "event" can occur per "trial." An "event" may be any kind of occurrence, a failure, a defective condition, etc. and a "trial" is a single instance of observing whether the event is present or absent.
	pn	The number of events, where only one event can occur per trial. (A single letter symbol is sometimes used for convenience in place of pn.)
	u	The ratio of the number of events to the number of trials under consideration, where more than one event can occur per trial, and a trial is a unit area of opportunity for occurrence of the event. An example is the number of pin holes per square foot; an event is the occurrence of a pinhole, a trial is the examination of one unit of area (1 sq. ft.), and the number of trials is the number of units of area (number of square feet) under consideration.
	c	The number of events, where more than one event can occur per trial. (See explanation accompanying definition of symbol u.)

*ASTM *Manual on Presentation of Data*, p. 30. Am. Soc. Test. Mat'ls., Phila., 1944; also ASA Z1.3, *Control Chart Method of Controlling Quality During Production*, p. 39. Am. Stds. Assn., 1942.

TERM	SYMBOL	DEFINITION
(b) Terms Relating to a Sample		
Note: The following terms relate to events commonly called "defects" and "defectives" in quality control work. Other terms, such as failures, breaks, etc., can be substituted as necessary.		
Defect		A failure to meet a requirement imposed on a unit with respect to a single quality characteristic; also an irregularity in material, surface, finish, etc.
A Defective		A defective unit; one containing one or more defects with respect to the quality characteristic(s) under consideration.
Sample Fraction Defective	p	The ratio of the number of defective units in a sample to the total number of units in the sample; the number of defectives in a sample of n units divided by n. Sometimes referred to as the sample "proportion defective."
Sample Number of Defectives	pn	The number of defectives in a sample. (A single letter is sometimes used for convenience in place of pn.)
Sample Defects per Unit	u	The ratio of the number of defects in a sample to the total number of units in the sample; the number of defects in a sample of n units divided by n; $u = c/n$.
Sample Number of Defects	c	The number of defects in a sample.
(c) Other Terms		
Average Value of p, pn, u **or** c	$\bar{p}$ $\overline{pn}$ $\bar{u}$ $\bar{c}$	The average of the set of sample values of p, pn, u, or c. Values of pn and $\bar{c}$ are computed for samples of equal size. For a set of samples of unequal size, p and u are weighted averages, usually obtained as follows: p is the total number of defective units found in the set of samples divided by the total number of units in the set; u is the total number of defects in the set divided by the total number of units in the set. These values are used in computing control limits for the case "No Standard Given."
Standard Value of p, pn, u, **or** c	p' $p'n$ u' c'	The value of p, pn, u, or c adopted as a standard for computing control limits for the case "Standard Given." (These symbols are also used to designate the true or objective value of p, pn, u, or c for the universe sampled.)
Standard Deviation of p, pn, u, **or** c	σ_p σ_{pn} σ_u σ_c	The standard deviation of the sampling distribution of p, pn, u, or c. $\sigma_p = \sqrt{p(1-p)/n}$ or $\sqrt{p'(1-p')/n}$ $\sigma_{pn} = \sqrt{pn(1-p)}$ or $\sqrt{p'n(1-p')}$ $\sigma_u = \sqrt{u/n}$ or $\sqrt{u'/n}$ $\sigma_c = \sqrt{c}$ or $\sqrt{c'}$

Comments: These terms, definitions and symbols have been adopted as standard for ASQC purposes. The following two departures from standard are authorized as optional, the first offering some convenience in mathematical discussions in the control chart field and the second providing alternative expressions and symbols for the control chart for standard deviations which may appeal to members of the Society familiar with the concepts of analysis of variance. Should either of these departures from standard gain wide acceptance, they will be considered when a revision of the Standard is undertaken.

(a) The Standard uses the same symbol, for example, X', for both a standard value and a universe value. Where a distinction is desired, it is suggested that the following symbols be used:

X', σ' etc.—universe values.

X'', σ'', etc.—standard values.

(b) If desired, for control charts for standard deviation:

for $\sigma = \sqrt{\frac{\Sigma(X-\bar{X})^2}{n}}$ substitute $s = \sqrt{\frac{\Sigma(X-\bar{X})^2}{n-1}}$

and for c_2 substitute c_4, where $c_4 = c_2\sqrt{n/(n-1)}$ and n is the sample size.

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REPORT OF THE

Fifth National Convention American Society for Quality Control

Cleveland, Ohio, May 23-24, 1951

THE Fifth National Convention of ASQC held in Cleveland on May 23rd and 24th was an outstanding success in every respect. The unprecedented attendance, which exceeded 2,500, is ample testimony to the growth of interest in Quality Control. Unofficial statistics indicate that 2,093 persons registered for the technical sessions and educational series. An additional 409 guests of exhibitors viewed the largest display of control equipment and quality control applications ever presented at an ASQC Convention. The registrants came from 35 states, with 24 coming from the Pacific Coast. Two provinces of Canada provided a delegation of 72 representatives from our northern neighbor. A registrant from Norway and one from India, the latter, Prof. P. C. Mahalanobis of the Indian delegation to the U. N. completed the international representation.

Despite the vast facilities of Cleveland's Public Hall where seating arrangements for 2,000 had been prepared for the technical and educational program, it was found necessary to post a Standing Room Only notice Thursday morning. This Fifth National Convention truly marks a milestone in the progress of the American Society for Quality Control.

PRE-CONVENTION SOCIAL EVENING

Early arrivals to the Fifth National Convention at Cleveland attended a Pre-Convention social evening on Tuesday, May 22nd. The refreshment bar in the Hotel Cleveland Ballroom opened promptly at 9:00 P.M. and continued serving refreshments long enough to break down the reserves of some 550 members and guests. A strolling accordionist accompanying a vocalist provided the entertainment which was aided and abetted by informal community singing.

ASQC Officers for 1951-52. Left to right: Wade R. Weaver, President; Simon Collier, Vice-President; Alfred L. Davis, Executive Secretary; Paul A. Robert, Treasurer.

During an intermission a skit was put on by Mr. Wagenhals and associates which dealt with quality control relations. Over 150 prizes, donated by various manufacturers, were distributed as door prizes. These included club aluminum ware, lighters, pictures, gift wrap assortments, and many other useful items.

GENERAL ASSEMBLY

The General Assembly, Wednesday morning, officially opened the Convention. Wade R. Weaver, President of ASQC and General Chairman of the Fifth National Convention, extended the official welcome and introduced Fred C. Crawford, President, Thompson Products, Inc., Cleveland, Ohio, who delivered a rousing keynote address. While expressing pleasure that the turnout of 1,500 people at the Assembly was indicative of the arousing interest of American industry in methods for quality control, Mr. Crawford cautioned that the American Society for Quality Control must not relax in its efforts to make management cognizant of the advantages of quality control by statistical methods. The future of America depends upon a continued increase in productivity. The factors which affect productivity are: (1) Machines and tools, (2) Method and quality control, (3) Worker efforts. Mr. Crawford then predicted that with sound government, management, and labor policies, the productivity of this country could be doubled in ten years and that this would merely provide a safety margin for our present lead in this field.

The function of the members of the American Society for Quality Control in this picture is to promote and disseminate among a greater proportion of management the knowledge and understanding of quality control. To emphasize the necessity for increased productivity, Mr. Crawford outlined the decline in

Speakers' table at the Thursday Luncheon Session featuring "Problems of Military Procurement." Rear Admiral M. L. Ring at the lectern.

England's productivity and its resultant effect. Some of the pitfalls in our path were colorfully described.

TECHNICAL PROGRAM

The appeal of the broad scope technical program presented at this Convention was evidenced by the attendance at all the sessions. Six technical sessions with anywhere from two to six speakers were presented simultaneously in each of three periods. Lively discussions followed the presentation of most papers and time restrictions had to be enforced. The combination of topics including training techniques, factory applications in various industries, consumer-vendor relationship, installing a quality control system and statistical theory provided a well balanced program. The subjects "What the Armed Services Expect of the Contractors' Quality Control Department" and "Principles and Practice of Military Standard 105-A" drew capacity audiences. The films which were shown at these particular sessions were of decided interest and should constitute valuable tools in training programs.

EDUCATIONAL SERIES

The Educational Series presented by Arthur Bender and George McDermott of Delco-Remy Division, General Motors, provided a fresh viewpoint which was stimulating both to those reviewing the subject as well as to those who were being introduced to quality control. Well over 200 people attended each of the four sessions. Discussions on the theory of control charts for both variables and attributes were supplemented by practice in the preparation of such charts. The many well chosen illustrations used held the interest of the group throughout the entire series. This introduction to the fundamentals of quality control unquestionably served to further the scope of ASQC and to promote knowledge of statistical quality control.

LUNCHEON SESSIONS

About 1,450 people attended each of the two luncheons. At the Wednesday luncheon, which was informal, those desiring to discuss mutual problems were afforded an opportunity to do so by the preassignment of tables for specific fields of interest. The formal luncheon on Thursday featured an address by Rear Admiral M. L. Ring, Director of Supply Management, Munitions Board, on "Problems of Military Procurement" which is reported elsewhere in this issue. A special entertainment feature served to emphasize that too much credulity should not be placed on things heard and seen without thorough personal investigation. The guests at the speakers' table constituted an imposing gathering of military personnel concerned with various phases of quality control. Leon H. Bass, Chairman of the Sixth ASQC Convention, extended an invitation to attend a similar affair in Syracuse next year.

ANNUAL BANQUET

The Annual ASQC Banquet was held in the Hotel Cleveland Ballroom. The 950 persons attending this affair were welcomed by Wade R. Weaver, General Chairman, who opened the program with a brief review of the growth of the Society. Mr. Weaver announced that in addition to an increase in membership, three new sections had been formed and several more groups were in the process of qualifying for section status. The financial position of the Society has also been very gratifyingly improved.

A special award of an Honorary Membership Pin was presented to George D. Edwards in cognizance of his status as Honorary Member. Arrangements had been made for the presentation of a similar pin to Dr. Walter A. Shewhart who is also an Honorary Member, but due to an unfortunate automobile accident Dr. Shewhart was unable to be present. The Brumbaugh Award was presented to Dr. Irving W. Burr, Professor of Mathematics, Purdue University, for his article "A New Method for Approving a Machine or Process Setting" published in Industrial Quality Control, Vols. V-VI. This award, named in honor of Dr. Martin A. Brumbaugh, founder of Industrial Quality Control, is presented each year to the author of that paper published in Industrial Quality Control judged by the Award Committee to have made the greatest contribution to the development of industrial applications of quality control.

Mr. Weaver then introduced Alfred L. Davis, Rochester Institute of Technology, who, after reviewing the history and significance of the Shewhart Medal Award, presented the following citation for this award to Dr. Martin A. Brumbaugh.

Shewhart Medalist Citation

The brief roster of distinguished Medalists whom the Society has proudly proclaimed in the past has challenged the committee this year to base its selection on the same high standards of performance and meritorious service. Yet by virtue of the fact that excellence is often known before it is announced, the choice has fallen upon a man the mere mention of whose name will be received with unanimous consent and wholehearted approval.

The Award for 1950 goes to Martin Allen Brumbaugh, founder of our journal, *INDUSTRIAL QUALITY CONTROL*, and friend to hundreds of members of this Society.

Born in Central Pennsylvania, September 8, 1896, he was educated in the schools of that state, completing his

Irving W. Burr receives 1950 Brumbaugh Award from President Wade R. Weaver

Martin A. Brumbaugh receives 1950 Shewhart Medal Award from President Wade R. Weaver

undergratuate work at Juniata College in 1918. This was followed with graduate work at the University of Pennsylvania, where he received his Master of Arts degree in 1921 and his Doctors Degree in 1926.

In 1929, he accepted the position of Professor of Statistics at the University of Buffalo, serving that University with distinction for a period of eighteen years.

For this Society, however, it is within the brief span of the last eight years that Martin Brumbaugh has made a contribution of such significance that he has been selected as our Man of the Year.

Many in this audience vividly recall the intensive training programs of the War Production Board. Many of us, including our Medalist, received our first introduction to Quality Control through those training programs. It was participation in one of these courses, offered in Buffalo in 1943, that brought the name of Brumbaugh into prominence. This experience was quickly followed by his joining the staff for courses presented at Syracuse, Kent State (serving the Cleveland area), and Tennessee, plus a continuing training program at his own University. It can be estimated that over 1200 men and women have had the benefit of his instruction in Quality Control.

Not only was he a master teacher, but he went into the plants of many of his students to work with them in applying these new statistical control methods to their problems. He was quick to grasp an understanding of shop procedures and processes and to carry these to his classroom in a manner which gave new and real meaning to his academic work.

The friendly qualities and high professional abilities that typify Dr. Shewhart, in whose honor this award was established, are also the great distinguishing characteristics of Martin Brumbaugh. The novice in quality control work feels free to seek his counsel. The professional statistician respects his ability and judgment. To both groups and the many in between he is Martin Brumbaugh, friendly, courteous, skilled in his profession and more than willing to assist an associate in the solution of problems.

While Martin Brumbaugh is the author of a number of books, it is our journal, *INDUSTRIAL QUALITY CONTROL*, which will be remembered longest and is possibly his greatest contribution to date to the quality control movement.

It has been my privilege to be in close touch with Martin for these past eight years. I believe I can speak with authority regarding the personal sacrifice required of him and members of his family to foster and nurture what was then a small, struggling journal. It is impossible to compute the hours he spent as Editor in writing and editing material, of giving friendly criticism to budding quality control authors, of preparing page layouts, of reading proof, of mailing the finished product, along with performing the innumerable duties of a business manager. It was truly his vision, his limitless energy and painstaking devotion to an idea that brought this magazine into being in July 1944.

Along with his editorial duties, Martin Brumbaugh carried on an active correspondence with interested men and women from all parts of the country, regarding the need for a national organization. It is not surprising to find an editorial on this subject appearing in the magazine in November 1944 and to later find him as chairman of the organizing meeting which launched the American Society for Quality Control, on February 16, 1946.

It was at this meeting that Martin saw the culmination of two of his fondest interests: First, a national organization was born which had as its purpose the serving of quality control operators and the establishment of control procedure as a recognized part of management. Second, *INDUSTRIAL QUALITY CONTROL*, having achieved national prominence, moved beyond its original conception as an information bulletin for the Buffalo Section to become the official voice of this Society.

It is impossible to assess the value of this magazine to our Society. It has become the strong link between all members and all sections of this organization. This Society owes our Medalist a great debt of gratitude for his work as Founder and first Editor of *INDUSTRIAL QUALITY CONTROL*. This debt was only partially repaid when the Brumbaugh Award was established in his honor in 1948.

An enthusiastic exponent of the need for a national society, Martin Brumbaugh has also been a tireless worker in our behalf. He has addressed over forty local section meetings as well as appearing on the program of several regional conferences and national conventions. Wherever he has gone he has served our Society well.

Harold Dodge and General L. E. Simon at the "Meet the Author" period in the Book Stall

E. L. Grant, Eugene H. MacNiece, and E. M. Schrock at the "Meet the Author" period in the Book Stall

He served as Editor of *INDUSTRIAL QUALITY CONTROL* until March 1947 and has continued to the present as a member of the Editorial Board. Elected a Fellow of the Society in 1946, he has since served as a member of the Examining Committee. He is currently Vice President of the Society. In connection with this Convention he has served as its able program chairman, presenting a roster of 50 speakers covering subjects of interest to every segment of the Society.

It was in 1947, after spending 28 years in university work, that he resigned his post at the University of Buffalo to assume full-time industrial duties as Director of Statistics with Bristol Laboratories of Syracuse, New York. Not only has he been a great teacher but he has demonstrated the importance of statistics and has successfully applied them to industrial problems. In this connection I asked Dr. Philip Bowman, Executive Vice President of Bristol, to write me concerning his work. This letter I should like to read at this time.

April 27, 1951

Mr. Alfred Davis
Rochester Institute of Technology
65 Plymouth Avenue South
Rochester 8, New York

Dear Al:

I was delighted to hear from you that Dr. Brumbaugh is to receive the Shewhart Medal this year. It is certainly fine recognition of the devotion he has shown toward furthering the cause of Industrial Statistics; and I am proud of him, both as a friend and as the operating head of a company that has used statistics to accelerate and to make more sound its progress.

It is due to Dr. Brumbaugh's work that Bristol Laboratories has earned a reputation as the leader in the drug field in this respect. This recognition is a great tribute to a man who has spent most of his life in academic work and who had the courage to go into industrial work in a new industry, with all its rough-and-tumble problems, at a time in his career when most men are content to "coast".

Martin's academic background, however, has stood him in good stead, for he has used it not only in solving specific problems but also in teaching many of our technical people to understand the value of, and to learn how to use, statistical methods.

This loyal group of devotees has carried statistics into all parts of our operations with gratifying success. All of them, with me, will be standing in tribute to Dr. Brumbaugh in spirit, if not in physical presence, when he receives the Shewhart Medal.

Sincerely yours,

BRISTOL LABORATORIES, INC.
Phil

P. I. Bowman
Executive Vice President

It is now my honor and pleasant duty to present the Shewhart Medalist for 1950, Dr. Martin Allen Brumbaugh.

Following these award ceremonies and by way of entertainment, Mr. Henry Pildner, alias Dr. J. C. Appleby, presented an erudite lecture, well illustrated by cosmic charts designed to explain in simple language atomic energy's impact on quality control or vice-versa. His well chosen but unintelligible remarks added a pleasant contrast to the more serious aspects of the Convention. Mr. Pildner, Musical Director of WGAR Station, Cleveland, completed his portion of the program with several excellent piano solos.

The Annual Meeting of the Society was reconvened to receive the teller's report on the election of officers for the next fiscal year. As a result of the balloting, Mr. Wade R. Weaver was re-elected President. The other electees were: Mr. Simon Collier, Vice President; Mr. Alfred L. Davis, Secretary; Mr. Paul A. Robert, Treasurer.

LADIES' PROGRAM

The special ladies' program prepared for those not attending technical sessions or other events of the Fifth National Convention was received with enthusiasm by those participating. A luncheon attended by 80 ladies on May 23rd, took place in The Higbee Company private dining lounge. Each guest was provided a corsage and the name plates issued each one made getting acquainted much easier. The style show put on immediately after the luncheon gave the ladies ideas for wardrobe planning in line with current trends in feminine fashions. Commentary was provided by Miss St. Andrews, stylist of The Higbee Company.

On Thursday, May 24th, approximately 60 ladies boarded two sightseeing buses. The tour itinerary covered the lake shore of Cleveland's East Side, several of Cleveland's parks and exclusive residential sections, and continued on through

noted Shaker Square and past the Marine Hospital and the East Side Water Reservoir. A short tour was made of Cleveland's Art Museum where the May Show was in progress. The world famous "Juno", the life size mannikin that talks and explains the body structure visible through its transparent body, was among the many things of interest seen during the visit to the Health Museum, which was the last stop on the tour.

EXHIBITS

The number, size, and quality of this year's exhibits were a further indication of the growth of interest in quality control. Numerous types of gages and optical aids for obtaining accurate measurements were displayed. Other equipment aids such as surface analyzers and calculating machines were also presented. Many examples of quality control at work were featured. These were all viewed with a great deal of interest by over 2500 people. A complete list of exhibitors follows.

BOOK BOOTH

Of special interest this year was the new feature of an SQC Book Booth where many of the outstanding quality control books were available for inspection and purchase. As an added attraction, arrangements had been made for some of the authors who were present at the Convention to autograph books purchased at this booth. The opportunity to meet these authors, plus the ready availability of a wide range of texts, enjoyed a most gratifying response from registrants at the Convention.

EXHIBITORS AT THE FIFTH NATIONAL CONVENTION

Bausch & Lomb Optical Co.
Berrettoni & Associates
Brown & Sharpe Mfg. Co.
Brush Development Co.
Cadillac Gage Co.
Hugh G. Collins
Cleveland Graphite Bronze Co.
Coca Cola Company
Do-All Co.
Elliott Service Co.
Engineer Specialties Div., Universal Engraving & Colorplate Co., Inc.
Engis Equipment Co.
Federal Products Corp.
Ford Motor Co.
Friden Calculating Machine Co.
General Electric Co.
Goodyear Tire & Rubber Co.
Graham-Mintel Instrument Co.
Greenfield Tap & Die Corp.
Johnson Gage Co.
Jones & Lamson Machine Co.
King-Seeley Corp.
Lamson & Sessions Co.
Magnaflux Corp.
Magnetic Analysis Corporation
Monroe Calculating Machine Co.
National Tool Co.
Ohio Rubber Co.
Physicists Research Co.
Pratt & Whitney Div., Niles-Bement-Pond Co.
Sheffield Corp.
L. S. Starrett Co.
Taft Peirce Mfg. Co.
Thompson Products, Inc.
Webber Gage Co.
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Military Procurement*

REAR ADMIRAL MORTON L. RING

Munitions Board

THIS discussion will be concerned with some of the problems of military procurement and the tying together of the several functions of supply management, not only within the Department of Defense (DOD), but, of almost equal importance, as between the DOD and the rest of the Federal Government.

My specific task is that of Military Director of Procurement and Distribution on the staff of the Munitions Board. I was given an additional task by the Secretary of Defense, to serve as the DOD working member in trying to get the General Services Administration and the DOD together, on a policy level, on the same problems of supply management. This endeavor represents a rather considerable contribution to what the taxpayers ought to be looking for, which is some business administration sense in a field that sorely needs business administration knowledge and techniques.

SUPPLY MANAGEMENT

Let us begin by defining what we shall mean by the phrase "supply management." First, out of the Hoover Commission Report comes this definition of supply: Supply is defined as "the task of providing . . . Supplies, materials, and equipment required for the operation of the Federal Government." Bearing in mind that the DOD operations within the above definition are the materiel support of an actual or potential combat force, it may be seen that supply management involves coordination of effort in the various fields of supply operations, be they command or noncommand operations, in order to obtain the maximum materiel support at minimum cost.

The several functions of supply management as they are generally understood in the Department of Defense encompass such things as procurement. In public Law 413, or the Armed Services Procurement Act, the Congress required that the Munitions Board assign the procurement function, to the greatest extent practicable, on what is known as a "single procurement" basis. We have a definition of single procurement. The narrow definition of course would mean that the Corps of Engineers of the Army is to buy all the lumber for all the services. While there are many examples of procurement assignments of that type, I think the basic intent of the Congress was to avoid competition between the several technical services of the Army and the Bureaus of the Navy and between departments, so that any sound form of procurement assignment that avoids overlap, duplication of effort, and competition is basically in response to the intent of the law. The last figure I saw, based on dollars and cents of our procurement budget, is that some 81 percent of our total expenditures are now handled under some form of coordinated buying.

In the endeavor to establish uniform policies relating to the procurement of supplies and services a series of Armed Services Procurement Regulations have been developed to guide the procurement officers of the Army, Navy and Air Force. Thirteen Sections of this regulation have been published and two other sections are in process.

CATALOGING AGENCY

We have a Munitions Board Cataloging Agency and in accordance with an agreement developed by representatives of the Budget Bureau, the General Services Administration and the Munitions Board, the Administrator of General Services has delegated his cataloging authority to the Chairman of the Munitions Board. The Director of the Cataloging Agency with power of decision, by the way, is working on a Federal Catalog and not just a Department of Defense catalog. It is a massive undertaking.

Maybe I ought to say right at the start that we are never going to print a catalog. We expect to do sufficient naming, numbering, and describing of items on five-by-eight cards so that in whatever form a bureau, technical service, or the Air Materiel Command wants to use it, each will call the same item by the same number. That is the final goal. I think we would be stupid to assume that today we can get out a card, and tomorrow everyone of the Ordnance Corps 150,000 blueprints is going to be changed, or everyone of its 5,000 storage bin tabs is going to be changed. They are not. We would completely disrupt the supply system by doing that. The end aim, however, is that wherever an item appears, wherever it is necessary to talk about this item, someday it will be called by one name, one number, and one description. What we propose to do in the interim is to cross-reference from the existing systems to the Munitions Board Cataloging Agency's system so that there will be a cross-reference approach to the final goal.

Because of the Korean conflict it was considered advisable to speed up the completion of the cataloging program. It is our hope that within another 10 months we will have gone through the identification phase of cataloging. We still have a lot of work to do in classification. We still have a lot of work to do considering the impact of the catalog system upon the existing supply systems. We are talking about something that would be on the order of 2.5 million cards when we get through.

Probably the most important thing we must watch while we are going through this next 10 month period and speeding up the completion of the identification phase is this: The military departments will be busily engaged with expanded procurement dollars, buying many more new items that we have never heard of before. If we are going to have a catalog system worthy of the name, we must establish a method of introducing those new items into the catalog system with proper description and proper numbering at the time of pro-

* Presented at the Luncheon Session, Fifth Annual ASQC Convention, Cleveland, Ohio, May 23, 1951

current. If we don't do that we will make the mistake that was made with the old Federal Standard Catalog, which was a fine still-camera picture of the items on hand at any given instant but did not include new current items.

SMALL BUSINESS

One of the problems always confronting us has to do with those two magic words "small business." And it is quite a problem. Small business as I see it gets along pretty well in normal peacetime. But at a time when limitation orders are cutting out certain civilian production a small businessman who is used to doing business as a subcontractor, or manufacturer of a specialty line, finds it rather difficult to get enough work, or the necessary materials to keep going.

Information has been passed on to the small businessman that the only thing to do is to come down to Washington to get a government contract, and that is where our trouble really starts, since the Munitions Board does not contract for material and also most of the buying is done outside of Washington. Many of them do not have the facilities to become prime contractors, although they can and do participate with tremendous effectiveness as subsuppliers. They may take small contracts for the simpler type of items. We have in the Munitions Board a Central Military Procurement Information Office to assist businessmen. It is designed to function as a central directing Service to guide businessmen to the persons they should see in Washington and in the Military Field offices concerning the sale of their products. This office does not assist in obtaining contracts.

As a further move to aid industry, especially small business, in planning for military production, the Army Ordnance Corps is setting up contract exhibits at its District Offices throughout the country. The exhibits will include samples, display boards, photographs and other essential information pertaining to ordnance items. The primary purpose of the exhibits is to offer small manufacturers an opportunity to examine in detail the representative component parts of the standard items of ammunition and material for which they have capacity to produce either as prime or subcontractors.

A contractor for aircraft engines reported to the Air Force regional procurement office his inability to obtain subcontractors. The regional office advertised the fact and gave office space to the contractor to interview potential subcontractors. Approximately 1,000 businessmen were interviewed and in three days a substantial number of subcontractors had been approved for the work. Such a procedure is beneficial to both prime and subcontractors.

STANDARDS AND SPECIFICATIONS

Let me touch next on the subject of standards and specifications. We have a Munitions Board Standards Agency which is busily engaged in developing a single Military series of specifications and engineering standards. Use by the Military Departments of MIL specifications in their procurement is a means toward standardization of military equipment. The problem of converting existing department specifications to the single MIL series is a considerable job. Emergency procurement has introduced many new items for which specifications are required thereby increasing the work to be handled by the Agency. There is also a Federal Specifications Board which develops federal specifications for commercial type items. Many of these specifications are used in military procurement. There are some 18,500 military and Federal specifications existant today. In the development of a single mil series many of the department specifications will be found to be duplications and the total number will be considerably reduced.

The question is often raised, "Why are military specifications so restrictive?" "Why don't we pay more attention to producibility and less to the military demands for specific departures from commercial standards?" It is a very persuasive argument. I was privileged to listen to a discussion between a former chairman of the Munitions Board, Mr. Carpenter, and a very important citizen from Chrysler. The Chrysler man was telling Mr. Carpenter, "Your military specifications for automotive vehicles are preventing us from really producing." And he had a wonderful argument that if we could accept commercial standard vehicles we could pretty nearly crush the enemy under the tonnage of the vehicles that we got.

There is the opposite side of the picture. Would the vehicles work in salt water or close to it? Would they work up north where they might have to work? Would they work in the desert sands? There is a very nice balance and a very high order of intelligence that should be applied to the military demand for those essential departures from civilian standards. The military representatives ought to be in a position to demand what they must have. They must not make industry's task of producing more difficult than it has to be. Industry has enough trouble anyway, with government contracts, without giving it that burden.

PACKAGING

The Munitions Board has a responsibility in packaging and on our staff there is a packaging division working to develop policies and programs for the standardization of preservation, packaging and packing methods and materials—to assist them in this field a very effective industry advisory committee has been organized. It is necessary for us to keep the closest possible contact we can with a finely organized industry group, so that the most modern techniques and advances in the art will be reflected in what we are trying to do. I was amazed when I was given figures sometime ago, and I think this will interest you, that nearly six percent of the procurement dollar allocated by Congress for the procurement of hard goods goes into packaging. That is a lot of money.

MATERIAL INSPECTION

In the material inspection field we will continue, through the activity of the Munitions Board Material Inspection Agency, our efforts to eliminate any duplication of inspection service and develop uniform inspection procedures for the Army, Navy and Air Force. Complaints from industry have been a lack of uniformity in acceptance of material by inspection services, the lack of properly trained inspectors, duplication of effort and too much 100% inspection, that is, little spot checking and use of statistical quality control. Industry has suggested that a unified inspection organization would go a long way toward eliminating major complaints as regards military inspection. It is not our intention to develop a single inspection service but to try to evolve a uniform procedure not only within the Department of Defense but some day as between the Department of Defense and the GSA so

that we can make the most efficient use of the inspection and testing facilities of the government.

The assignment of procurement responsibility to a single department or service has been a means of promoting uniformity of inspection and eliminating duplication since the department or service having been assigned commodity procurement also has the responsibility to arrange for inspection. It is further required that in arranging for inspection consideration shall be given to the government inspection service available at the plant in question.

The Departments have established training courses for inspectors and this training includes courses in the use of statistical methods for quality control. Wide use is being made of quality control methods by the Departments and wherever applicable and desirable MIL-STD-105A (Sampling Procedures and Tables for Inspection by Attributes) is referenced in specifications or contract for use in determining acceptability of products procured by the government.

The Material Inspection Agency is monitoring a long range program to establish basic aspects to improve quality assurance and quality control standards and procedures for the Department of Defense. A moving picture film "High Quality Through Statistical Methods" has been completed. It was developed as an introduction to the use of statistical methods for quality control. As such, it is valuable in the training of inspectors and in promoting the use of statistical methods in inspection.

DISTRIBUTION

The last subject I shall mention we call "distribution." I think a good distribution system could well be called the keystone of the supply structure. It deals with storage, maintenance, issue, and movement of supplies. Its function includes the means of applying materiel controls to assure positive coordination of plans and action necessary to provide effective materiel support for military operations.

CONCLUSION

As the nation moves into a major defense effort such as the present one or per adventure into an all-out war, the quantity of materiel required increases very rapidly. These large quantities of materiel must be of the right quality. Quality cannot be sacrificed in the interest of quantity. A large supply of guns which will not function properly or which quickly break down in the field could mean the loss of an undertaking. Obviously it would impair morale of troops and possibly the security of the nation. I am not contending that we have reached the acme of military inspection. We are constantly striving for greater efficiency and that which in turn simplifies the operation and leads to economies for the contractor.

You gentlemen in ASQC play a key role in attaining this goal of large quantities and high quality. To the extent that better quality control systems are developed and widely accepted by industry, the quicker will we realize our goal. You will be making a great contribution to our national security.

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Now you can keep track of complex inspection techniques with the Continuous Sampling Monitor . . . newest addition to the General Electric line of instruments developed to improve your quality control program.

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GENERAL ELECTRIC

A Comparison of Military Standard 105A with the 1944 Army Services Forces Sampling Procedures and Tables and with JAN-Standard 105

SEYMOUR J. LORBER EUGENE L. GRANT

Stanford University

"Military Standard 105A—Sampling Procedures and Tables for Inspection by Attributes" was adopted by the Department of Defense in September 1950. This standard was printed for general use in December 1950 and is for sale by the Superintendent of Documents, Washington, 25, D. C., at a price of 30 cents. It is evident that the new standard is likely to be used in the acceptance inspection of many billions of dollars worth of items purchased by the Army, Navy, and Air Force. Moreover, like the earlier military standards, MIL-STD-105A will doubtless have a great influence on acceptance procedures used in industry. Many people in government and industry will therefore need to understand it.

A substantial fraction of these people already have some familiarity with one or more of the earlier military standards for acceptance sampling by attributes. Perhaps the two standards most widely known are the 1944 version of the Army Service Forces tables and JAN-STD-105, the Department of Defense standard superseded by MIL-STD-105A. The former was an outgrowth of the original Army Ordnance tables developed in 1942 with the advice of distinguished engineers from the Bell Telephone Laboratories. The latter was originally developed by the Statistical Research Group of Columbia University for use by the Navy; in an earlier issue JAN-STD-105 was Appendix X of the Navy's "General Specifications for Inspection of Material."

Understanding of the new standard should be helped by a recognition of the points of similarity and the points of difference as compared to these two earlier and more familiar standards. The authors of this article have prepared a report on this topic. Interested persons may secure a copy of this report by writing to Dr. Herbert Solomon, Mathematics Branch, Office of Naval Research, U. S. Navy Department, Washington, 25, D. C. The following material is a greatly abbreviated summary of this report. In the interests of brevity, the standards are referred to as ASF, JAN-105, and MIL-105A.

SOME POINTS OF SIMILARITY AMONG THE STANDARDS

The general objectives and methods of the three standards are similar. A brief listing of certain points of similarity follows:

1. All three standards require that product submitted for inspection be divided into lots. The decision on the acceptance or rejection of each lot depends on the inspection of a sample (or samples) taken from the lot. The acceptance criteria used may also depend on the quality of samples from preceding lots.

2. All three standards provide for classifications of defects with separate acceptance decisions made for each class of defects. The terminology of classification of defects differs among the standards, however. The dependence of acceptance criteria on the class of defects inspected also differs.

3. To determine the acceptance criteria in all three standards, it is necessary to establish the sample size, the type of sampling (single, double, or multiple) and the acceptable quality level (AQL).

4. The sample size in all three depends on the lot size submitted for inspection. However, in JAN-105 and MIL-105A the sample size also depends on a decision on the inspection level.

5. All standards permit either single or double sampling. JAN-105 and MIL-105A also permit multiple (sequential) sampling.

6. All three standards involve the possibility of normal, tightened, or reduced inspection, with the decision on tightened or reduced inspection influenced by the quality history of the product.

7. All the standards permit conventional attributes acceptance inspection with the decision on acceptance or rejection of a lot dependent on the number of *defectives* found in a sample. In addition, ASF provided a separate table for acceptance decisions based on number of *defects*. JAN-105 made no mention of acceptance based on defects. MIL-105A provides that the same tables applicable to acceptance decisions based on numbers of defectives may also be used for acceptance decisions based on numbers of defects. One segment of MIL-105A is aimed primarily at acceptance decisions based on numbers of defects.

SOME POINTS OF DIFFERENCE AMONG THE STANDARDS

The following tabulation tries to present in compact form the most important points of difference among the standards. The reader should recognize that in this compact presentation a number of the points of difference are necessarily somewhat oversimplified.

	ASF (1944)	JAN-105	MIL-105A
Classification of defects	Critical—Major—Minor—Incidental	Critical—Major—Minor A—Minor B	Critical—Major—Minor
Acceptance criteria for minor defects for stated AQL	More lenient than for majors	Same as majors	Same as majors
Types of sampling	Single and double	Single, double, and sequential (multiple)	Single, double, and multiple (sequential)
Availability of procedures based on defectives and on defects—per-unit	Table based on defectives with minimum sub-lot size of 500; separate table based on defects-per-unit for sub-lots of 499 or less	Procedures based entirely on defectives with no minimum lot size	Same tables are applicable to percent defective and defects per 100 units; no minimum or maximum lot size for either
Lot size divisions for lots of 300 or more	Almost identical for all three standards	Almost identical for all three standards	Almost identical for all three standards
Lot size divisions for lots below 300	8 divisions	5 divisions with different end points from ASF	8 divisions with end points almost identical with ASF
Inspection levels in establishing sample size for any given lot size	Only one inspection level	Levels I, II, III, IV, and V. Ratios to ASF sample size are 0.5, 0.75, 1, 1.5, and 2	Levels I, II, III. Most frequent ratios to ASF sample size are 0.5, 1, and 2
Designation of sample size by code letter	No code letters	Code letters A to 0	Code letters A to Q. Letters J to Q correspond respectively to H to O in JAN-105
Definition of Acceptable Quality Level (AQL)	". . . the maximum percent defective which can be considered satisfactory as a process average."	"Percentage of defective items in an inspection lot such that the sampling plan will result in the acceptance of 95% of submitted inspection lots containing that percentage of defective items."	". . . a nominal value expressed in terms of percent defective or defects per hundred units whichever is applicable, specified for a given group of defects of a product."
AQL range	0.005%—5.0% for percent defective; 0.0026%—2.0% for defects per unit	0.024%—6.4%	0.015%—10.0% for percent defective; up to 1000.0 defects per hundred units
Designation of AQL classes	By blocks, such as 0.51%—1.0%	By blocks, such as 0.65%—1.2%	By points, such as 1.0%. (Auxiliary Table I converts intermediate AQL values to designated point values.)
Spacing of AQL classes	Four classes below 0.06%; five classes 0.061%—1.0%; four classes 1.1%—5.0%.	Two classes below 0.06%; six classes 0.06%—1.2%; five classes 1.2%—6.4%.	Points approximately in geometric progression and multiples of 1, 1.5, 2.5, 4.0, and 6.5
Probabilities of acceptance of submitted lot having exactly AQL % defective under normal inspection	Aimed-at value is 0.95 except for largest sample sizes where it reaches 0.98.	Aimed-at value is 0.95 for all sample sizes	Aimed-at value progresses from about 0.80 for smallest sample sizes to about 0.998 for largest sample sizes.
Relative severity of acceptance criteria at smallest sample sizes under normal inspection	Small sample sizes not available in percent defective plans	Less severe	More severe
Relative severity of acceptance criteria at intermediate sample sizes under normal inspection	Practically no difference	Practically no difference	Practically no difference

	ASF (1944)	JAN-105	MIL-105A
Relative severity of acceptance criteria at largest sample sizes under normal inspection	Intermediate in severity	Most severe	Least severe
Preference for type of sampling Relative severity of acceptance criteria under tightened inspection	Double sampling preferred Generally most severe of the three standards for lowest AQL values.	No preference expressed Generally most severe of the three standards for intermediate and highest AQL values.	No preference expressed. Generally least severe of the three standards for all AQL values.
Upper limit of process average to determine shift from normal to tightened inspection.	3-sigma limit based on point value of AQL	1.96-sigma limit from upper boundary of AQL class	3-sigma limit based on point value of AQL
Shift of how many AQL classes in going from normal to tightened inspection.	One to four	Two	One
Return from tightened to normal inspection	When process average is better than AQL value	When process average is equal to or better than lower boundary of AQL class	When process average is equal to or better than point value corresponding to AQL class
Types of sampling and sample sizes under reduced inspection	In single sampling, one-fifth of normal. In double sampling, first sample is one-fifth of normal; second sample size makes total sample same as normal.	In single, double, and sequential, sample sizes are half of normal on inspection levels III, IV, and V, two-thirds of normal for level II, and no reduction on level I.	All reduced sampling is single sampling. Sample size is one-fifth of single sample size in normal inspection.
Relative severity of acceptance criteria in reduced inspection	Generally intermediate in severity	Generally most severe	Generally least severe
Lower limit of process average to determine shift from normal to reduced inspection	Lower boundary of AQL class	1.96-sigma limit below lower boundary of AQL class	3-sigma limit below point value of AQL
Designation of quality level where acceptance criteria are based on defects rather than on defectives.	Defects-per-unit (AQL values from 0.0026% to 2.0%)	No such acceptance criteria mentioned in this standard	Defects-per-hundred units (AQL values up to 1000.0)
Relative severity of acceptance criteria based on defects.	Slightly less severe	———	Slightly more severe
Mention of AOQL values for each set of acceptance criteria	Yes	Yes	No

Corrections and Additions to the Schwartz-Kaufman Paper, March 1951 Issue

The March issue of INDUSTRIAL QUALITY CONTROL contained an article entitled "Determining Conformance with Requirements for Lot Averages" by D. H. Schwartz and P. Kaufman. The article included operating characteristic curves for sample sizes 6 to 20. The curves for sample sizes 2 to 5 were inadvertently omitted from the publication.

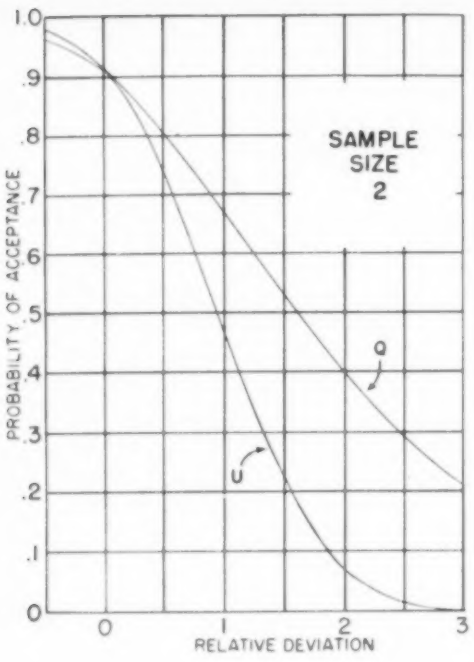
In addition to this, the curves furnished for the "Q" test were incorrectly scaled. The values on the horizontal scale (relative deviation), although correct for the U-Test, should have been divided by $\sqrt{n}$ for the "Q" test.

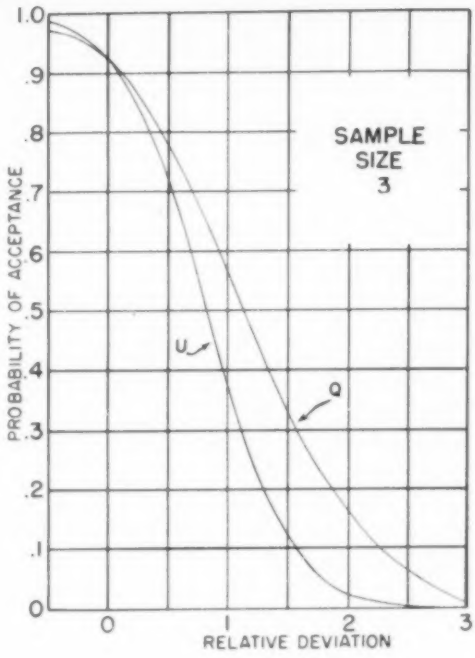
The correct curves for sample sizes 2 to 20 are furnished on pages 30 and 31 of this issue.

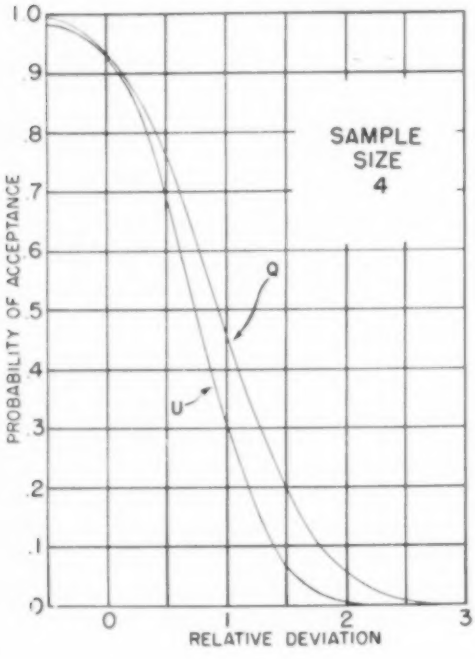
The authors and the editorial staff offer their sincere regrets for this incident and hope that the readers have not been greatly inconvenienced.

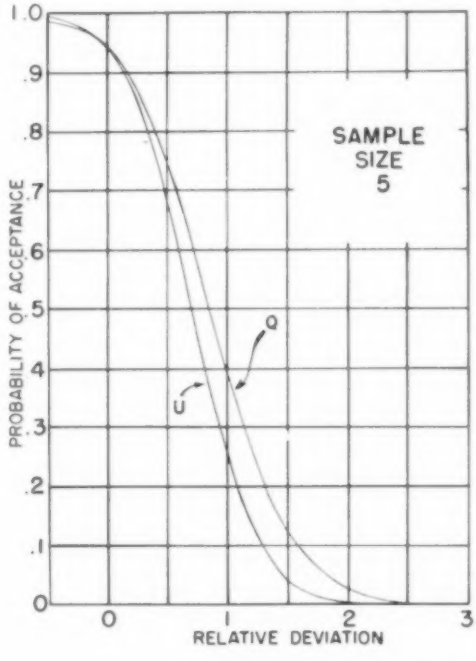
From the correctly plotted OC curves, it can be seen that the "Q" test offers considerably more discrimination between good and bad quality than was originally indicated. For this reason, the "Q" test can be more highly recommended than was done in the original manuscript of the article which appeared in the March issue.

OPERATING CHARACTERISTIC CURVES FOR U & Q TESTS

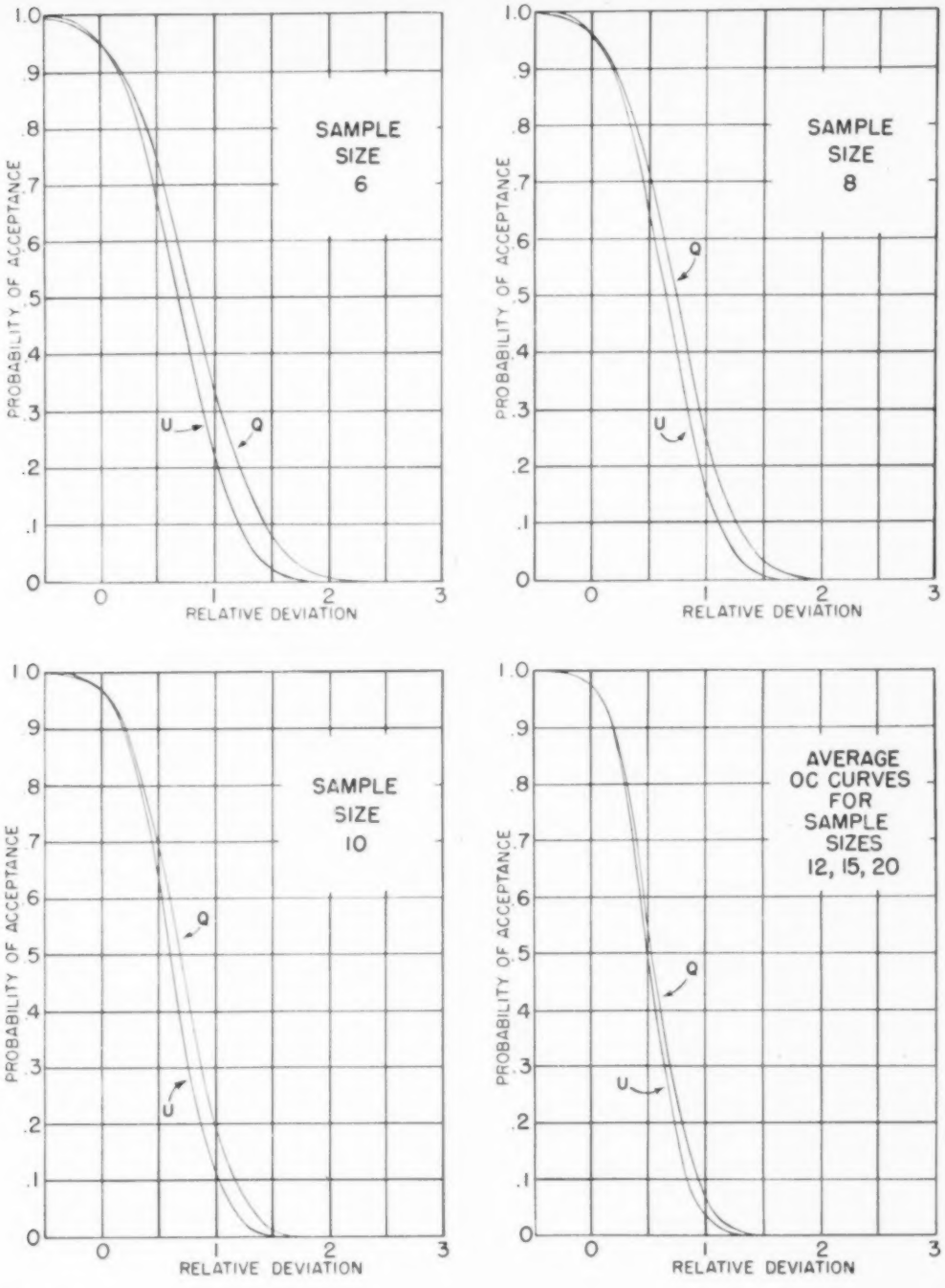








OPERATING CHARACTERISTIC CURVES FOR U & Q TESTS



The Frequency of Selecting Samples for Attribute Testing

A. C. COHEN, JR.

The University of Georgia

CONTROL charts are employed primarily for detecting the presence of assignable causes of an undesirable nature in production processes. Thus they act as regulating mechanisms for controlling quality. By selecting samples at proper intervals, it is also possible to employ effectively control chart data for the secondary purpose of deciding on product disposition; i.e. deciding whether to ship, reinspect, rework, or scrap. A simple method, applicable to inspection by attributes, is presented in this paper whereby the frequency of selecting samples can be determined so that this secondary purpose will be served while maintaining predetermined risks of making the wrong decisions. It should be pointed out that we are concerned with in-process inspections rather than with the acceptance inspections of incoming materials.

Our problem quite naturally involves the probability that a given individual sample will fail to detect the existence of a cause which is producing defective items; also the probability that the existence of such a cause will remain undetected for k consecutive samples; and the related problems of sample size and the permissible risks of making wrong decisions associated with varying percentages of defective product.

If the probability of failing to detect the presence of "trouble" in the process with the first sample selected after it entered (i.e. the probability of not obtaining any individual point beyond control limits) is P, then the probability, β, of failing to detect the presence of such "trouble" for k consecutive samples is given by

$$\beta = P^k. \qquad (1)$$

The complementary probability that the trouble's existence will be indicated by at least one of the first k samples selected following its appearance is $1-\beta$. To express k explicitly as a function of P and β we take logarithms of both sides of (1) and obtain

$$k \log P = \log \beta,$$

from which it follows that

$$k = \log \beta / \log P. \qquad (2)$$

A nomograph* for solving this equation is given in Figure 1. As an example of its use, note that for $P = 0.74$ and $\beta = 0.05$, $k = 10$. This means that even though the probability of failing to detect the presence of "trouble" in the first sample is as high as .074, the probability that the presence of this trouble will remain undetected while 10 consecutive samples are selected is not more than 0.05.

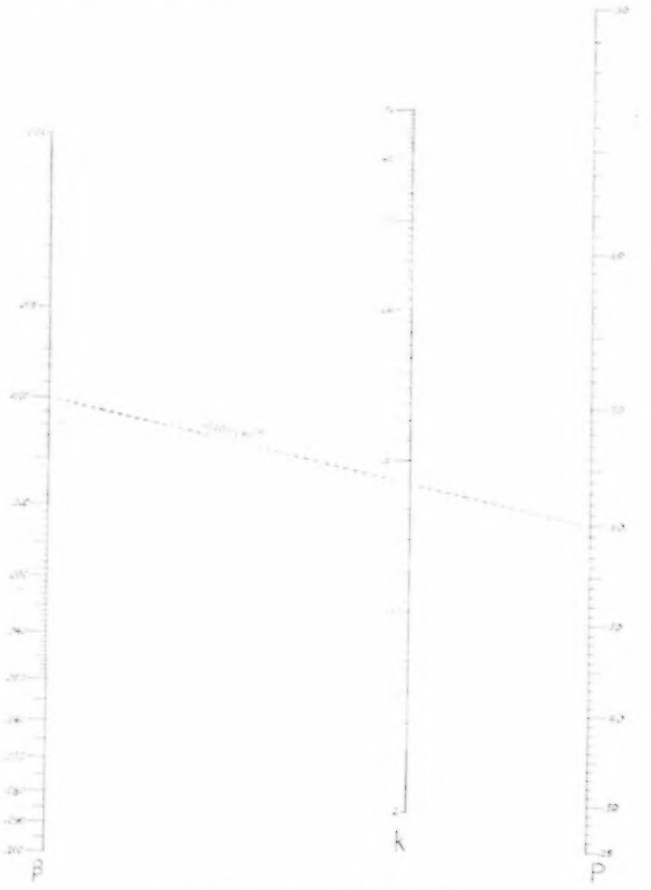


Figure 1—**Nomograph for $\beta = p^k$**

The probability P that an individual sample will fail to disclose the presence of trouble in the process is

*This monograph was developed by Dr. David Barrow of the University of Georgia and I am indebted to him for his permission to use it here.

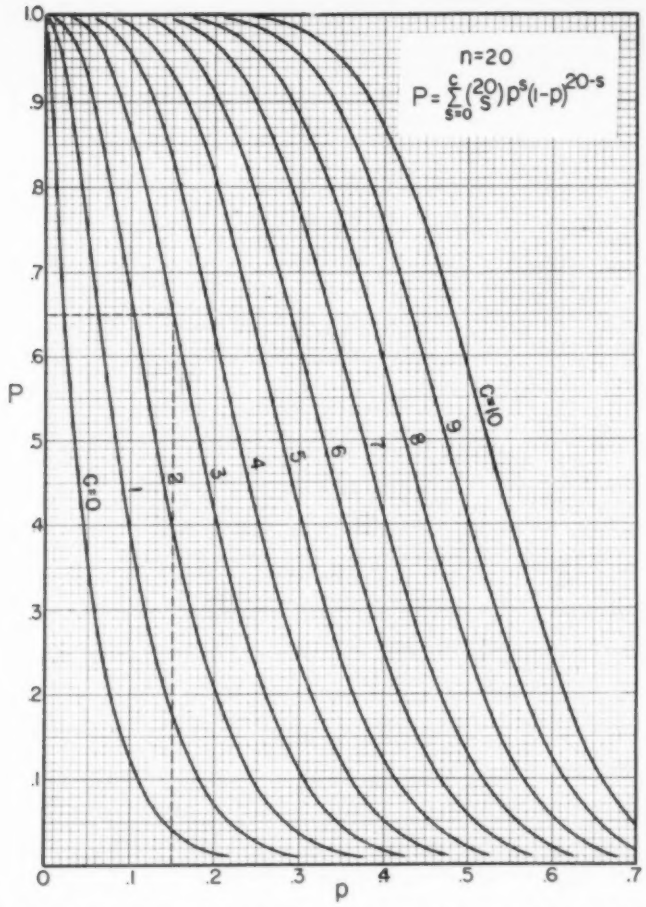


Figure 2—**Operating Characteristic Curves. Probability, P, that a single sample will contain not more than c defectives as a function of the fraction defective, p, being produced.**

of course a function of the seriousness of the trouble. This relation is defined by the Operating Characteristic Curve (OC Curve) which depends only on the control limits and the sample size. OC Curves have been widely discussed in connection with various plans for acceptance inspections. The same notions with regard to OC Curves which apply to acceptance sampling are applicable in the present case. However, the action taken is different. On finding an unsatisfactory sample in making acceptance inspections, the first action is to reject the lot, whereas similar findings in process inspections demand that we first seek to identify and remove the manufacturing source of trouble and then perhaps decide whether to reject, rework, or pass the lot.

A typical set of OC Curves for $n = 20$ with upper control limits (acceptance numbers) chosen to be $c = 0, \ldots, 5$ is included in Figure 2. The process average, p, (fraction defective) is plotted along the horizontal axis and the probability P that an individual sample will contain not more than c defectives (i.e. that an individual sample will fail to register trouble) is plotted along the vertical axis. It is to be noted from these curves that as the degree of seriousness of trouble increases (that is, as p increases), the value of P decreases for all values of c. For samples other than of size 20, the corresponding OC Curves can be constructed as described in numerous sources. For example, Grant [1] describes their construction in Chapter XIII, pp. 342-347, where they are referred to simply as characteristic curves. The recently published binomial tables [2] should prove helpful to anyone who has occasion to construct such curves.

Before demonstrating explicitly how the foregoing considerations are utilized in determining the frequency of sample selection, we will set forth the following definitions.

- N = Total number of items in a "Production Run" (corresponds to a lot).
- n = Number items in an individual sample.
- k = Number of samples to be selected per "Production Run".
- p = Fraction of defective items being produced at any given time.
- p_s = Standard (allowable) fraction defective.
- c = Upper control limit (acceptance number).
- p_c = Maximum fraction defective that can be tolerated in an acceptable Production Run during the production of which, k samples are selected).

A "Production Run" is defined as any convenient group of consecutively produced items. It may consist of a varying quantity which is identified with a fixed time interval or it may simply consist of any N consecutive items to be produced.

In general p_s will be the average fraction defective of the production line as determined from past experience over a long period of time. It may, however, be a standard established by management in defining the desired (i.e., *target*) quality level.

We let c be the usual upper control limit for a number-defective control chart determined for given values of p_s and n. It may either be determined as a 3σ limit or as some fixed probability limit. With c determined, regardless of the method used, an OC Curve can be prepared which will disclose the probability that an individual sample will fail to register trouble of any given magnitude as measured by the fraction of defective items being produced.

In determining n, it is often advisable to give greater weight to administrative factors than to the statistical considerations involved. As a rule of thumb, twenty is ordinarily considered a minimum sample for attribute inspections, but even this may sometimes be reduced to perhaps ten or fifteen for urgent reasons of production. Samples of fifty or more are usually preferable in the light of statistical considerations. Any loss of sensitivity in detecting the presence of trouble in the production line due to a reduction of n can be restored by increasing k.

Let it now be assumed that n, p_a, and c have been selected in accordance with the preceding paragraphs, and that we wish to calculate k. We must, of course, agree on a satisfactory value for p_t and the permissible probability, β, which defines the risk of failing to detect trouble of a magnitude which results in $p = p_t$ from at least one of k consecutive samples. These values would ordinarily be determined from management decisions based on factors that are largely economic with due regard for the consequences of passing a faulty item. Typical values of β are of the order of 0.01 or 0.05.

With n, p_a, c, p_t, and β known, we determine k as follows:

1. Enter the appropriate OC Curve for the given values of c and n with $p = p_t$, and read the value of P along the vertical axis.
2. With P and β thus known, read k directly from the nomograph of Figure 1. For a more accurate determination of k, we might employ equation (2). When k is found to be fractional, we take the next largest integral value.

With k thus determined, we may be assured that whenever trouble which is serious enough to cause $p = p_t$ enters the production process, then the probability that this trouble will remain undetected long enough for a complete Production Run of N items to be produced is less than or at most equal to β. Furthermore, for every Production Run from which k consecutive samples of n were inspected with none exhibiting points beyond control limits, we can be assured that the probability is less than or at most equal to β that the Production Run contains as large a fraction defective as p_t.

Example: From a given production line, for which a fraction-defective control chart is maintained, it is desired to select periodic samples of 20 items each with such frequency that $\beta = 0.05$ and $p_t = 0.10$ when $p_a = 0.02$, and the Production Run consists of all items produced during one shift. With $p_a = 0.02$ and $n = 20$, the value of c is determined in the usual manner to be 2. From the OC Curve (Figure 2), we find $P = 0.67$ when $p = p_t = 0.10$. From the nomograph of Figure 1, we then find $k = 8$ when $P = 0.67$ and $\beta = 0.05$. Thus for each shift during which 8 samples are selected with none exhibiting points beyond control limits, the probability is less than or at most equal to 0.05 that as much as 10% of the shift's production is defective.

Whenever a point on the control chart falls beyond the control limit and thus indicates the presence of trouble in the process, it also casts suspicion regarding the quality of recent production which can be removed only after further inspection. The quantity of production thus placed under suspicion might be reduced to that produced during some short interval of operation if the time at which the trouble entered the process can be definitely established. Even when this time cannot be accurately fixed, it is necessary only that the items produced during the period while the previous k samples were being selected be subjected to further inspection. In order to maintain prescribed quality levels under these circumstances, it is suggested that the additional inspections required be determined from standard acceptance sampling tables. Of course, in some practical applications, it might be more feasible simply to make a 100% inspection of the suspected production.

— NOTICE —
TRANSACTIONS AVAILABLE

Additional copies of the book "Quality Control Conference Papers," containing most of the technical papers presented at the 1951 ASQC Convention, are still available at $3.50 each. Order and remittance (made out to the American Society for Quality Control) should be sent to Alfred L. Davis, Rochester Institute of Technology, Rochester 8, N. Y.

It is of course recognized that the sensitivity of any control chart in detecting shifts of quality levels can often be materially increased if, in addition to watching for points beyond control limits, attention is also directed to runs above or below the mean, or to moving averages of several of the most recent consecutive samples. The use of Simon's Grand Lot technique also serves to accomplish the same objective. When additional criteria such as these are employed, the net effect is to decrease the probability, P, of failing to detect the presence of "trouble" in our process, and accordingly the value of k as determined in this paper will tend to be somewhat larger than is actually necessary to provide the required protection under these conditions. Conversely, for a fixed value of k as determined herein, it follows that when runs or other auxiliary detection techniques are employed, we gain added protection against overlooking the presence of trouble; i.e., for fixed values of k and p_t the corresponding value of β is lowered or for fixed values of k and β, then p_t is lowered.

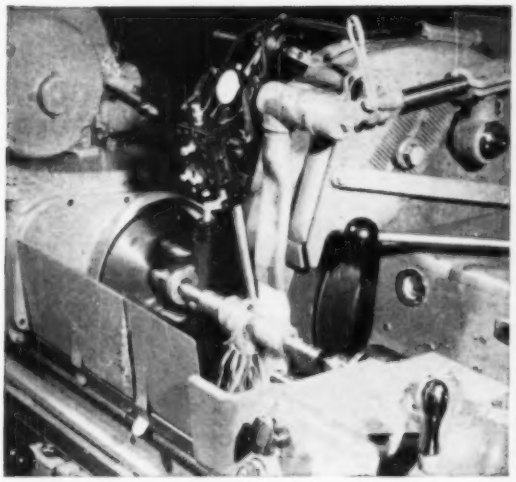
In any given application of the Control Chart, it is generally recommended that full advantage be taken of the techniques mentioned above for thus increasing our chances of detecting trouble before its effects become unduly serious. However, since other writers have discussed these techniques rather fully, and since they are not of primary concern in the present paper, no further discussion will be included here.

The frequency of selecting samples can be determined in a similar manner when sampling by variables if the necessary OC Curves are available. The writer hopes to consider this problem further in a subsequent paper.

References

[1] E. L. GRANT, *Statistical Quality Control*. McGraw Hill Book Company, Inc., New York, 1st ed., 1946.

[2] *Tables of Binomial Probability Distribution*. National Bureau of Standards, Applied Mathematics Series 6, U. S. Government Printing Office, Washington, D. C., 1950.



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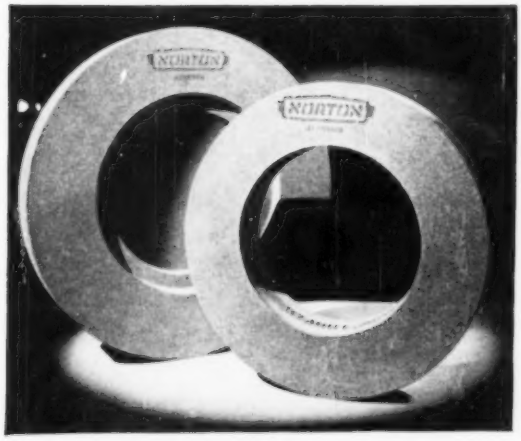

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A Method for Determining the Most Economic Position of a Process Mean

C. H. SPRINGER

Purdue University

INTRODUCTION

In many industrial processes it is found that the variability of the process is so large relative to the specified tolerances that a considerable fraction of the product will fail to meet these specifications. In cases where there are both upper and lower specifications, it is probable that the financial loss due to producing a piece above the upper specification will not be equal to the loss due to producing a piece below the lower specification. Because of this inequality, the total cost of all rejected product will depend greatly on the position of the process mean with respect to the specifications. In this paper a simple method is given for determining the optimum position for this mean value, which minimizes the total cost of rejection in two cases, for a normal population and for an unsymmetrical one, the Pearson Type III. The mathematical derivation of the method is given in the Appendix. It is assumed that the process will operate in statistical control at a given level and with known standard deviation.

NOTATION

The following notation has been used:

- $\bar{X}'$ = the process average.
- σ' = the process standard deviation.
- U = the upper specification on the product.
- L = the lower specification on the product.
- C_U = the cost of rejecting a piece having $X > U$.
- C_L = the cost of rejecting a piece having $X < L$.
- k = the third standard moment of the process distribution*.

For a sample of size n,

$$k = \frac{1}{n(\sigma')^3} \sum_{i=1}^{n} (X_i - \bar{X}')^3.$$

TABLE I—Values of the factor W—Normal Distribution

$\frac{C_L}{C_U}$	$(U-L)/\sigma'$								$\frac{C_L}{C_U}$
	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
.005	−0.87	−0.27	0.24	0.68	1.07	1.44	1.79	2.12	200
.010	−0.59	−0.01	0.43	0.85	1.23	1.58	1.91	2.23	100
.020	−0.31	0.20	0.63	1.02	1.38	1.72	2.04	2.35	50
.050	0.05	0.50	0.89	1.25	1.58	1.90	2.21	2.50	20
.100	0.33	0.73	1.09	1.42	1.74	2.04	2.33	2.62	10
.200	0.61	0.96	1.29	1.60	1.89	2.18	2.46	2.73	5
.500	0.97	1.27	1.55	1.83	2.10	2.36	2.62	2.88	2
1.000	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	1

$\bar{X}' = L + W\sigma'$ $\qquad$ $\bar{X}' = U - W\sigma'$

PRODUCT DISTRIBUTED NORMALLY

In the special case where the product is distributed normally about its mean with standard deviation σ', the position of the process mean which minimizes the total cost of rejection is given by the formulas

(a) $\bar{X}' = L + W\sigma'$, when $C_L \leq C_U$;

(b) $\bar{X}' = U - W\sigma'$, when $C_L \geq C_U$.

The factor W depends on the two ratios C_L/C_U and $(U - L)/\sigma'$, which are pure numbers without units. W is found in Table I for commonly occurring values of these two ratios.

It should be observed that formula (a) must be used only when the cost ratio above is less than unity, W being found by entering the left side of Table I. If the cost ratio is greater than unity, formula (b) must be used, and Table I entered on the right.

In the special case where $C_L = C_U$, it is interesting to observe that formulas (a) and (b) both give the result $\bar{X}' = \frac{1}{2}(U + L)$. This is the value that is midway between the upper and lower specifications, just as would be anticipated.

Linear interpolation for W in Table I is accurate enough for most practical purposes, the average error being not more than two points in the second decimal place.

EXAMPLE 1

Control charts for the boring operation on a rough casting have shown the process in good control. The specifications on this diameter are $3.1250'' \pm 0.0010''$. From past data σ' is estimated to be $0.00050''$. It is further estimated that the cost of scrapping a casting because of oversize diameter is about twenty times the cost of reworking an undersized one. If the distribution of diameters is assumed to be normal, at what value should the mean be set in order to have the total cost of rejected castings as small as possible? The computations are:

$C_L/C_U = 0.05$; $(U - L)/\sigma' = 4.0$. From Table I, $W = 1.25$. Since $C_L < C_U$,

$$\begin{aligned} \bar{X}' &= L + W\sigma' \\ &= 3.12400'' + (1.25)(.00050'') \\ &= 3.124625''. \end{aligned}$$

*For further information about k, see the *ASTM Manual on Presentation of Data*, American Society for Testing Materials, (1940), pages 17 to 38, or *Industrial Quality Control*, March 1950, pages 26 and 27.

This value, perhaps rounded to four decimal places, is the desired mean value.

If it is arbitrarily assumed that the cost of scrapping a casting is $2.00 and the cost of reworking one is $0.10, the total average cost of rejected product can be calculated.

If $\bar{X}'$ had been set at the mid-value of the specification, 3.1250", then 2.3% of the castings could be expected to be scrapped, and 2.3% of them could be expected to need reworking. For each 100,000 castings machined, this would be a cost of (2300) ($0.10) + (2300) ($2.00) or approximately $4800.

If $\bar{X}'$ were, instead, set at the value computed above, 10.6% of the castings could be expected to be reworked and only about 0.3% of them scrapped. The total cost in this case for the same number processed would be

(10,600) ($0.10) + (300) ($2.00),

or about $1700. This represents a saving of about 65% of the former cost of rejection.

PRODUCT DISTRIBUTED AS PEARSON TYPE III

The Pearson Type III distribution has been used to typify a skewed population, since it is representative of many non-symmetrical distributions met in practice. The use of the method for locating the optimum position of the mean in this case requires the determination of k, the third standard moment of the product distribution, in addition to the two ratios already used in the normal curve case.

Two formulas are again used, as follows:

(a) $\bar{X}' = L + W\sigma'$ when $k > 0$;

(b) $\bar{X}' = U - W\sigma'$ when $k < 0$.

The factor W depends on the three unitless numbers $C_\pm/C_+$, $(U-L)/\sigma'$, and k, and is tabulated in Table II for various values of the two ratios and for k equal to ± 0.3, ± 0.7, and ± 1.1.

When k is positive, formula (a) must be used, and W found from Table II by entering from the left side; for negative k, formula (b) is used, with W being found in Table II entering from the right side.

Linear interpolation in Table II for intermediate values of the three variables will be satisfactory for most purposes. Also, since Table I is for the normal curve which is the limiting form of the Pearson Type III as k approaches zero, interpolation between Tables I and II may be used for values of k between zero and ± 0.3. The two tables in conjunction thus enable one to find W for any k between -1.1 and $+1.1$.

TABLE II—Values of the factor W—Pearson Type III Distribution

k	$C_\pm/C_+$	(U—L)/σ' 2.5	3.0	3.5	4.0	4.5	5.0	5.5	$C_\pm/C_+$	k
	.01	−1.15	−0.39	0.17	0.62	1.00	1.33	1.63	100	
	.05	−0.09	0.40	0.80	1.14	1.45	1.72	1.97	20	
	.10	0.29	0.70	1.05	1.35	1.62	1.87	2.10	10	
	.20	0.63	0.97	1.27	1.54	1.79	2.02	2.23	5	
	.50	1.04	1.31	1.55	1.78	1.99	2.20	2.40	2	
+0.3	1	1.32	1.54	1.74	1.95	2.14	2.33	2.52	1	−0.3
	2	1.58	1.75	1.93	2.11	2.28	2.46	2.63	.50	
	5	1.89	2.01	2.15	2.31	2.46	2.62	2.78	.20	
	10	2.10	2.20	2.31	2.45	2.59	2.73	2.88	.10	
	20	2.30	2.37	2.47	2.58	2.71	2.84	2.98	.05	
	100	2.71	2.73	2.79	2.87	2.97	3.08	3.20	.01	
	.01	−3.02	−1.20	−0.26	0.35	0.78	1.11	1.38	100	
	.05	−0.33	0.31	0.75	1.08	1.34	1.55	1.74	20	
	.10	0.27	0.71	1.04	1.30	1.52	1.70	1.86	10	
	.20	0.71	1.03	1.29	1.50	1.68	1.83	1.96	5	
	.50	1.15	1.36	1.54	1.71	1.85	1.98	2.09	2	
+0.7	1	1.40	1.56	1.71	1.84	1.96	2.07	2.17	1	−0.7
	2	1.60	1.72	1.84	1.95	2.06	2.15	2.24	.50	
	5	1.81	1.90	1.99	2.08	2.17	2.25	2.32	.20	
	10	1.94	2.02	2.09	2.17	2.24	2.31	2.37	.10	
	20	2.06	2.11	2.18	2.24	2.30	2.37	2.42	.05	
	100	2.26	2.29	2.33	2.38	2.43	2.47	2.51	.01	
	.01		−4.92	−1.24	−0.02	0.61	0.98	1.23	100	
	.05	−0.79	0.24	0.76	1.08	1.29	1.44	1.54	20	
	.10	0.30	0.79	1.09	1.29	1.44	1.54	1.62	10	
	.20	0.85	1.12	1.31	1.44	1.54	1.62	1.67	5	
	.50	1.24	1.38	1.49	1.57	1.64	1.68	1.72	2	
+1.1	1	1.41	1.51	1.58	1.64	1.68	1.72	1.75	1	−1.1
	2	1.53	1.59	1.65	1.69	1.72	1.75	1.76	.50	
	5	1.63	1.67	1.70	1.73	1.75	1.77	1.78	.20	
	10	1.68	1.71	1.73	1.75	1.77	1.78	1.79	.10	
	20	1.72	1.74	1.76	1.77	1.78	1.79	1.80	.05	
	100	1.77	1.78	1.79	1.79	1.80	1.81	1.81	.01	

$\bar{X}' = L + W\sigma'$ $\bar{X}' = U - W\sigma'$

This interpolation is straightforward if $k>0$ and $C_t \leq C_r$ or if $k<0$ and $C_t \geq C_r$. However, if $k>0$ and $C_t>C_r$, or if $k<0$ and $C_t<C_r$, the value found in Table I corresponding to $k = 0$ must be subtracted from $(U-L)/\sigma'$ to obtain the required value for interpolation; this fact is a consequence of the condensed form in which Table I is presented.

For example, suppose that $(U-L)/\sigma' = 4.5$, $C_t/C_r = 20$, and W is desired for $k = +0.1$. From Table II, $W_{.3} = 2.71$ for $k = +0.3$. From Table I, where k equals zero, $W_0 = 4.50 - 1.58 = 2.92$. Thus for $k = +0.1$, $W = 2.92 + (0.1)(2.71 - 2.92)/0.3 = 2.92 - 0.07 = 2.85$.

A similar procedure must be followed if $k<0$ and $C_t<C_r$. In any case, the formula to be used for $\overline{X}'$ will be determined by the sign of k, i.e., $\overline{X}' = L + W\sigma'$ when $k>0$, and $\overline{X}' = U - W\sigma'$ when $k<0$.

EXAMPLE 2

Suppose that in Example 1 the distribution were not normal, but skewed with $k = +0.7$. At what point should the mean now be set for minimum rejection cost? The calculations are:

$C_t/C_r = 0.05$ $(U - L)/\sigma' = 4.0$

From Table II, $(k = +0.7)$: $W = 1.08$.

Since $k>0$, $\overline{X}' = L + W\sigma' = 3.12400'' + (1.08)(0.00050'') = 3.124540''$. This is the optimum position for the mean.

Assume, as before, a unit scrap cost of \$2.00 and a unit rework cost of \$0.10. For this distribution, if the mean were set at the nominal of 3.1250", then 0.3% of the castings could be expected to need reworking and 3.8% of them could be expected to be scrapped.* For each 100,000 castings machined, the total average cost of rejection would be

$$(300)(\$0.10) + (3800)(\$2.00)$$

or about \$7600, practically all due to scrap.

On the other hand, if the mean were set at the value computed above, then 12.8% of the castings would be expected to need reworking, while only about 0.9% of them would be scrapped. The total average cost of rejection for the same number of castings processed would now be only

$$(12{,}800)(\$0.10) + (900)(\$2.00)$$

or about \$3100, representing a saving of about 60% of the former cost of rejection.

*These percentages and those in the next paragraph may be obtained from tables of areas of the Pearson Type III. See, for example, *Statistical Tables*, edited by H. C. Carver, Edwards Bros., Ann Arbor, Michigan, or L. R. Salvosa, Tables of Pearson's Type III Function, *Annals of Mathematical Statistics*, Vol. 1, No. 2 (May 1930), p. 191.

MATHEMATICAL APPENDIX

Consider an arbitrary continuous probability function $f(t)$, where t has zero mean and unit variance. The following expression for the total expected unit cost of rejected product can be written:

$$C(\overline{X}') = C_t \int_{-\infty}^{\frac{L-\overline{X}'}{\sigma'}} f(t)\,dt + C_r \int_{\frac{U-\overline{X}'}{\sigma'}}^{+\infty} f(t)\,dt .$$

When C_t, C_r, U, L, and σ' are known, this is a function of the mean, $\overline{X}'$. The value of $\overline{X}'$ for which the cost C will be minimized will be the solution of the equation obtained by setting the derivative of C with respect to $\overline{X}'$ equal to zero, i.e.,

$$C_t f\left(\frac{L-\overline{X}'}{\sigma'}\right)\left(-\frac{1}{\sigma'}\right) - C_r f\left(\frac{U-\overline{X}'}{\sigma'}\right)\left(-\frac{1}{\sigma'}\right) = 0$$

which may be written

$$\frac{C_t}{C_r} = \frac{f\left(\frac{U-\overline{X}'}{\sigma'}\right)}{f\left(\frac{L-\overline{X}'}{\sigma'}\right)} .$$

From this general result it is seen that the total cost will be minimized for any parent distribution of product when the distribution is located in such a manner that the ordinates of the frequency function at the upper and lower specifications are inversely proportional to the costs of rejection outside these points. Also, this relationship does not depend on the actual costs C_t and C_r themselves, but only on the ratio between them.

Before proceeding to the derivation of the formulas for the two special cases treated here, it would be well to consider the conditions under which a solution of the equation just derived gives a unique absolute minimum.

In order for the solution to give a minimum value of C, it is sufficient that the second derivative of C with respect to $\overline{X}'$ be greater than zero at the point where the first derivative is zero. The condition on the second derivative actually is

$$C_t f'\left(\frac{L-\overline{X}'}{\sigma'}\right) - C_r f'\left(\frac{U-\overline{X}'}{\sigma'}\right) > 0 .$$

Combining this with the condition for a zero first derivative previously found, it is sufficient that the inequality that follows be true:

$$\frac{f'\left(\frac{L-\overline{X}'}{\sigma'}\right)}{f\left(\frac{L-\overline{X}'}{\sigma'}\right)} > \frac{f'\left(\frac{U-\overline{X}'}{\sigma'}\right)}{f\left(\frac{U-\overline{X}'}{\sigma'}\right)} .$$

Thus if

(1) $f(t)$ is required to be unimodal, then it is clear that the solution is a unique one, so that if a minimum exists, it is absolute.

(2) $\frac{f'(t)}{f(t)}$ is required to be always decreasing with t, then the last inequality is satisfied since $U > L$, and the solution is a minimum.

These two restrictions on $f(t)$ are sufficient to ensure that the solution is the desired one. It is readily verified that the two functions considered, the normal and Pearson Type III with $|k| < 2$, both meet these requirements.

Now, if $f(t) = \frac{1}{\sqrt{2\pi}} e^{-t^2/2}$, the normal distribution, substitution in the first formula derived yields

$$\frac{C_t}{C_r} = e^{-\frac{(U-\overline{X}')^2 - (L-\overline{X}')^2}{2(\sigma')^2}} .$$

Taking natural logarithms of both sides of this equation leads to

$$-2(\sigma')^2 \log_e\left(\frac{C_t}{C_r}\right) = (U-\overline{X}')^2 - (L-\overline{X}')^2 .$$

Solving for X' in this last equation gives

$$X' = \frac{U+L}{2} + \frac{(\sigma')^2}{U-L} \log_e \left(\frac{C_L}{C_U}\right).$$

At this point it is readily seen that when C_L/C_U is unity, the logarithm term is zero, giving $\overline{X}' = \frac{1}{2}(U+L)$, as previously noted.

By rewriting the last expression in two different ways, the following formulas are found:

(a) $\overline{X}' = L + W\sigma'$ where

$$W = \frac{1}{2}\left(\frac{U-L}{\sigma'}\right) + \left(\frac{\sigma'}{U-L}\right) \log_e \left(\frac{C_L}{C_U}\right);$$

(b) $X' = U - W'\sigma'$ where

$$W' = \frac{1}{2}\left(\frac{U-L}{\sigma'}\right) - \left(\frac{\sigma'}{U-L}\right) \log_e \left(\frac{C_L}{C_U}\right).$$

It can easily be shown that W and W' are equal for reciprocal cost ratios, so only W has been tabulated in Table I.

Pearson's Type III distribution is represented by the equation $f(t) = C(t+A)^{A^2-1} e^{-At}$, where C is a constant and $A = \frac{2}{k}$. Substitution of this expression in the first formula yields

$$\frac{C_L}{C_U} = \frac{\left(\frac{U-X'}{\sigma'} + A\right)^{A^2-1} e^{-A\left(\frac{U-X'}{\sigma'}\right)}}{\left(\frac{L-X'}{\sigma'} + A\right)^{A^2-1} e^{-A\left(\frac{L-X'}{\sigma'}\right)}}.$$

By combining the exponential factors, and taking the $\frac{1}{A^2-1}$ power of both sides of the equation, this becomes

$$\frac{\frac{U-X'}{\sigma'} + A}{\frac{L-X'}{\sigma'} + A} = \left(\frac{C_L}{C_U}\right)^{\frac{1}{A^2-1}} e^{\frac{A}{A^2-1}\left(\frac{U-L}{\sigma'}\right)}.$$

Let the right side of this equation, which does not involve $\overline{X}'$, be called Y. Multiplying numerator and denominator of the fraction on the left by σ' gives

$$\frac{A\sigma' + U - \overline{X}'}{A\sigma' + L - \overline{X}'} = Y.$$

Solving this equation for $\overline{X}'$, and replacing A by its equivalent $\frac{2}{k}$, gives

$$X' = \frac{2\sigma'}{k} + \frac{LY - U}{Y - 1}.$$

By rewriting the last expression in two different ways, two formulas for X' are found:

(a) $\overline{X}' = L + W\sigma'$ where $W = \frac{2}{k} - \frac{U-L}{(Y-1)\sigma'}$;

(b) $\overline{X}' = U - W'\sigma'$ where $W' = -\frac{2}{k} + \frac{Y(U-L)}{(Y-1)\sigma'}$.

It can be shown that W and W' are equal for reciprocal cost ratios and k of opposite sign, so only W has been tabulated in Table II.

A New System of Vendor Quality Rating

BARTON KOSLOW **LAWRENCE LUTZKER**

Quality Control Engineers, Television Receiver Manufacturing Division, Allen B. DuMont Laboratories, Inc.

THE manufacture of a line of television receivers necessitates the use of over a thousand parts, each part being supplied by one or more vendors. In order to avoid being buried by a mountain of information and still obtain an accurate picture of the quality of product that each vendor was submitting, it became necessary to devise a system that would:

a. present incoming quality information in a simple and concise manner;
b. point out the vendors requiring special attention on quality problems;
c. high-spot the particular parts that were of exceptionally poor quality.

The procedure described below fulfilled these requirements.

A. The Individual Part Rating for each Part-Vendor Combination is

TABLE I—**Individual Part Number Rating**

First Sample Avg. Percent Defective	Rating		
	Description	Letter	No.
Three or more classes better than AQL class	Excellent	AAA	1
Two classes better than AQL class	Very Good	AA	2
One class better than AQL class	Good	A	3
At AQL class	Fair	B	4
One class worse than AQL class	Poor	C	6
Two classes worse than AQL class	Very Poor	D	10
Three or more classes worse than AQL class	Unsatisfactory	F	14

Note: 1. Any part number of a vendor receiving an F rating will be recommended for deletion from the approved list.

2. Any part number of a vendor receiving a C or D rating will be placed on a probationary list which will be reviewed for further action.

TABLE 2—**Quality Classes**

Percent Defective
0—0.035%
0.035—0.06
0.06—0.12
0.12—0.17
0.17—0.22
0.22—0.32
0.32—0.65
0.65—1.2
1.2 —2.2
2.2 —3.2
3.2 —4.4
4.4 —5.3
5.3 —6.4
6.4 —8.5

found as follows:

1. Summarize the lot-by-lot record for each part-vendor combination as shown in Figure 1.
2. Determine the average percent defective found in the first samples inspected during the summary period. (e.g., in Figure 1, the first sample average percent defective is 7/1635 or 0.43%).
3. The percent defective is next converted into a quality rating by determining its position with respect to the AQL (Acceptable Quality Level) class from Table 2, and finding the equivalent rating in Table 1. (e.g., from Table 2, it is found that .5% AQL falls into the class .32-.65%. The average percent defective found in the inspected first samples, being 0.43%, falls into the same class. From Table 1, it is found that a part, having a quality at the AQL class, receives a descriptive rating of "Fair," a letter rating of "B" and a numerical rating of "4". One of these ratings is then entered in the lot-by-lot record as shown in Figure 1. If the average percent defective had been 2%, this would have fallen into the 1.2-2.2% class. Since this is two classes above the AQL class of .32-.65%, the ratings would have been "very poor", "D", and "10".)

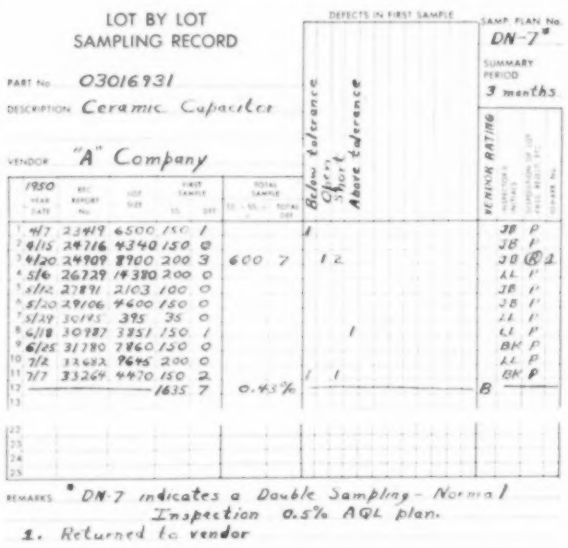
B. The composite rating for each vendor and component type is found as follows:

1. Average the individual part numerical ratings to find the quality level rating of the vendor.
2. Classify the vendor's quality level rating for the particular component type according to Table 3. (e.g., Vendor A, submitting ten part numbers falling under

TABLE 3—**Composite Vendor Quality Rating**

Quality Level	Letter	Description
1.00—1.49	AAA	Excellent
1.50—2.49	AA	Very Good
2.50—3.49	A	Good
3.50—4.49	B	Fair
4.50—5.49	C	Poor
5.50—6.49	D	Very Poor
6.50—up	F	Unsatisfactory

Note: Any vendor receiving a rating of C or worse will be investigated, and as many poor quality components as possible will be recommended for deletion.


LOT BY LOT
SAMPLING RECORD

PART No. 03016931
DESCRIPTION Ceramic Capacitor
VENDOR "A" Company

DEFECTS IN FIRST SAMPLE: Below tolerance; Open, Short; Above tolerance

SAMP. PLAN No. DN-7*
SUMMARY PERIOD 3 months
VENDOR RATING

	1950 YEAR DATE	REC. REPORT No.	LOT SIZE	FIRST SAMPLE			TOTAL SAMPLE				VENDOR RATING
					Below tolerance	Open, Short	Above tolerance				
1	4/7	23419	6500	150	1						JB P
2	4/15	24716	4340	150	0						JB P
3	4/20	24909	8900	200	3	600	7	1	2		JB (R) 2
4	5/6	26729	14380	200	0						LL P
5	5/12	27871	2103	100	0						JB P
6	5/20	29106	4600	150	0						JB P
7	5/29	30195	395	35	0						LL P
8	6/8	30987	3351	150	1			1			LL P
9	6/25	31780	7860	150	0						BK P
10	7/2	32683	9645	200	0						LL P
11	7/7	33269	4470	150	2	1	1				BK P
12				1635	7	0.43%				B	
13											
22											
23											
24											
25											

REMARKS * DN-7 indicates a Double Sampling - Normal Inspection 0.5% AQL plan.
1. Returned to vendor

Figure 1—**Part-Vendor Lot-by-Lot Quality Record**

Rank Order	Item & Company	Numerical Rating	Description
	PAPER CAPACITORS		
1	H Company	1.2	Excellent
2	C Company	2.8	Good
3	B Company	3.2	Good
4	A Company	4.1	Fair
5	D Company	5.8	Very Poor
	CERAMIC CAPACITORS		
1 & 2	C Company	1.0	Excellent
	B Company	1.0	Excellent
3	H Company	2.4	Very Good
4	E Company	6.8	Unsatisfactory

APPENDIX

No. 2101987—Paper Capacitor
D Company—F Rating, 2.6% defective due to shorts, off tolerance.
No. 2106801—Ceramic Capacitor
E Company—F Rating, 6.8% defective due to leads too short, high voltage breakdown.

Figure 2—**Vendor Ratings for Capacitors**

the component type "Ceramic Capacitors", has a quality level rating of 1.30. His letter rating found in Table 3 would be "AAA" and his descriptive rating would be "Excellent.")

3. Arrange all vendors' quality level ratings for the component type in the order of best quality. (e.g., see Figure 2)
4. For cases where only one part is included in a type for a vendor use the individual part rating (Table 1) as a composite rating.

C. Reporting Vendor Quality

1. A typical report (Fig. 2) includes:
   a. A rank order rating of each vendor within each component type. (Fig. 2—first column).
   b. A quality level and descriptive rating for each vendor within each component type.
   c. An appendix listing individual poor quality parts (those with a 'C' or worse rating) that require action, and the reasons for the poor quality.
2. It is recommended that the following parties receive vendor rating information:
   a. The plant manager.
   b. Purchasing Manager and Buyers.
   c. All Quality Control and Inspection Managers.
   d. Manufacturing Manager.
   e. Salvage Committee.
3. Summary Period
   The summary period for ratings will vary with the particular needs of the consumer. In general, between two and six months has been found most convenient.
4. Annual Ratings
   An annual rating for each vendor within each component type can be obtained by averaging the periodic composite quality level ratings that the vendor has received.
5. Master Vendor Ratings
   The Master Vendor Rating is a master average of all component types supplied by a vendor. Master Ratings can be prepared periodically or yearly. They are especially recommended in cases where a vendor supplies a homogeneous line of component types. Using Master Ratings for a vendor who supplies heterogeneous products does not seem advisable, although if an adequate system of weighting component types were used it might prove feasible.

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D. Action on Vendor Ratings (see notes in Tables 1 and 3)

The most important step in any vendor quality program is obtaining action when poor quality becomes apparent. The wide variety of conditions and circumstances from one company to another precludes any specific recommendations on what action to take. However, it is extremely important to remember that the ultimate success or failure of any vendor quality program will be determined by what action is taken.

It is implicit in any vendor rating procedure that quality is only one aspect of the picture. Cost is the other. No automatic quality rating system can be a substitute for sound judgment. However, only after obtaining vendor ratings and comparative prices for a series of comparable vendors can this judgment be properly exercised. It should be noted that this rating system does not preclude consulting economic factors before final action is taken by the Quality Control Department.

In presenting the above vendor rating procedure, it is apparent that some important points have not been fully discussed. The first point was the decision to use performance relative to the AQL as a means of rating a vendor. This seems most logical in view of the fact that the AQL is the mark both consumer and vendor use as a guide for acceptance. For anyone using Columbia type sampling plans*, the AQL classes provided (see Table 2) are suitable and convenient for the purpose of classifying vendor quality. With a few slight mechanical changes this vendor rating procedure can be adapted to the new Military Standard Plans**. If it is thought desirable, the consumer can tailor the quality classes to conform to his particular needs.

Another important aspect of the rating system is the selection of numerical weights for the individual part rating. If the classes worse than the AQL are not weighted 6, 10, and 14 (see Table 1), but are assigned weights of 5, 6, and 7, a vendor with an equal number of 'Excellent' and 'Unsatisfactory' parts would obtain a composite rating of 'Fair'. With the weighting of 6, 10, and 14 the vendor receives a composite rating of 'Unsatisfactory', which is more in accord with his just deserts. Actual selection of the weights used was made after extensive experimentation. The weights were selected with the idea of providing a linear composite scale, so that a difference of X units in composite rating would have a similar economic significance at any part of the scale.

To summarize, the rating system adopted accomplished the objectives:

a. Reporting vendor quality to management in a brief and easily interpreted form. Figure 2 illustrates how a large number of parts can be reported upon without requiring management to wade through a mass of data.
b. Making it easy for management to see which vendors require action due to poor quality.
c. Making it easy for management to know which parts require special action because of poor quality.

Sampling Inspection, SRG, Columbia University. McGraw-Hill, 1948. These plans are also in use by the Armed Forces.

**Military Standard Sampling Procedures and Tables for Inspection by Attributes, MIL-STD-105A, Sept. 11, 1950. Superintendent of Documents, U. S. Gov't. Printing Office, Washington, D. C.

Book Reviews

A. C. Cohen, Jr., *Editor*

ASTM MANUAL ON QUALITY CONTROL OF MATERIALS

American Society for Testing Materials, 1916 Race Str., Philadelphia 3, Pa. 127 xii pp.; $1.75. Review by Paul C. Clifford, State Teachers College, Montclair, N. J.*

This new ASTM Manual on Quality Control of Materials takes the place of the widely used ASTM Manual on Presentation of Data. The new manual is organized in three parts, each part bearing the statement "Endorsed by the American Society for Quality Control." The manual was prepared by the ASTM Technical Committee E-11, consisting of 23 members, practically all of whom are also members of ASQC. The chairman of the committee was Harold F. Dodge.

As is to be expected, this manual is of the highest calibre. It is not a text book on Statistical Quality Control, but with proper explanation and discussion it might be useful as a text. Its great use will be as a handbook of techniques.

Part 1 of the manual concerns Presentation of Data. This section discusses the statistical methods used to condense the essential information contained in a single set of observations, assuming the data are homogeneous. It presents the methods for tabulating data, for graphical presentation of data, and for computing such statistics as the average, the standard deviation and the skewness. In addition, it indicates the amount of relevant information contained in such statistics.

Part 2 is titled "Presenting ± Limits of Uncertainty of an Observed Average." This is a revision of a similar section in the old manual. One major change is the introduction of

*See special boxed notice accompanying this review.

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NOTICE

By virtue of the close cooperation between ASTM and ASQC and the active participation of numerous members of our Society on the ASTM Committee E-11 that prepared this Manual, members of ASQC may secure copies of it at the special price of $1.50. Send your order and remittance (made out to American Society for Quality Control) to

Alfred L. Davis
65 Plymouth Ave. So.
Rochester 8, N. Y.

the term "confidence limits". When the old manual was first written, this term was not generally accepted. A convenient table giving 90%, 95% and 99% confidence limits is included. In this table the formula for n greater than 25 is an approximate one, but this is not indicated. In addition, this section represents some working rules regarding the number of places to be retained in computation and presentation of averages, standard deviations and confidence limits.

Part 3 on "The Control Chart Method of Analysis and Presentation of Data" now consists of 64 pages instead of 20 as in the older publication. All of the necessary tables for routine control charts are given, and in addition a four page note on the derivation of the factors has been added. Considerable material has been added on the control chart for number of defectives, for number of defects, and for number of defects per unit. In addition, there is included material on control charts for individuals.

There are some 25 examples completely worked out in this section. They exemplify a wide field of applications, both as to material and as to type of problem. Each is illustrated by a control chart and several of them are illustrated by various combinations of control charts. Thus the lack of control on a range or average chart may be illustrated by a chart for individuals. Example 22 is of the type that most texts would treat by analysis of variance. The reviewer is most happy to see it treated very satisfactorily by control charts. In general, it will be almost impossible to find a better set of examples to illustrate the usual types of problems encountered in control chart work.

Except for two minor misprints there were no errors noticed. There is, however, one problem that worries this reviewer slightly. Example 1 gives a set of data that is in control. Example 12 discusses the same set of data with respect to a given standard. Under this analysis two points are out of control. The manual does cross-reference these two problems but it does not discuss one fundamental question: should we say that there is lack of control on two days, or should we say that there is control, but not at the desired level? In general, the ASTM is to be congratulated on the excellence of this manual. It is one of the most useful references in the entire field.

Bibliography

JOSEPH MOVSHIN, Editor

Assisted by the Editorial Committee, St. Louis Section, ASQC

On matters concerning the Bibliography Department, send correspondence, suggestions, and contributions to: Mr. Joseph Movshin, 9220 Old Bonhomme Road, St. Louis 24, Mo.

APPLICATION—ELECTRICAL INDUSTRY

THE CONTROL CHART AS A TOOL FOR ANALYZING EXPERIMENTAL DATA, Enoch B. Ferrell, Bell Telephone Laboratories, New York.

(Proceedings of the Institute of Radio Engineers, v. 39, n. 2, Feb. 1951, p. 132)

This article gives a description of the $\overline{X}$ & R chart and points out how the experimenter can use it in the laboratory in connection with developments of new designs. Applications to radio tube design are given. Several charts are included.

STATISTICAL EVALUATION OF LIFE EXPECTANCY OF VACUUM TUBES DESIGNED FOR LONG LIFE OPERATION, Eleanor M. McElwee, Sylvania Electric Products Inc., Kew Gardens, L. I., N. Y.

(Proceedings IRE, v. 39, n. 2, Feb. 1951)

In certain cases, vacuum tubes with a life expectancy of 5000 hours are desired, rather than the usual 500 hours. Actual 5000 hour test are impractical and so far a satisfactory accelerated life test has not been found. So a statistical analysis based on the 500 hour test was tried. Sufficient correlation was found to justify further study of this plan. Several charts and tables are included.

APPLICATION—METALLURGICAL INDUSTRY

STATISTICAL ANALYSIS OF OPEN HEARTH DATA, Wade R. Weaver, Director of Steel Conservation and Quality Control, Republic Steel Corp.

(Iron & Steel Engineer, Feb. 1951, p. 51)

Examines a few simple methods available for statistical analysis to see what they can do to eliminate "guesstimation" and replace "thinking and considering" with specific and factual answers. By making use of these methods, supervision would be in a position to make the best possible use of its time and effort, be able to crack the tough problems, and the melt shop supervision would have an easier and happier lot.

APPLICATION—MISCELLANEOUS

HOW TO MAKE QUALITY CONTROL WORK (A Special American Machinist Report to the Metal-Working Industries)

(American Machinist, v. 95, n. 9, April 30, 1951, p. 99)

This report covers in detail the history, development and present application of Quality Control at Thompson Products, Inc. The weakness of earlier programs, training for quality control, and the place of quality control in an organization are discussed in some detail. Present applications described include the reduction of scrap in the Accessories Division; the use of acceptance sampling based upon good dimensional control in the Valve Division; and the use of well planned forms.

An outline of quality control techniques used, their application, and their purpose is an interesting feature of this article.

The importance of training is stressed throughout.

BETTER QUALITY COSTS US LESS WITH STATISTICAL CONTROL, Ray W. Good, Director of Quality Control, Robertshaw-Division of Robertshaw-Fulton Controls Co., Youngwood, Pa.

(Factory Management, v. 109, n. 4, April 1951, p. 82)

The use of sampling (sequential) in place of 100% inspection resulted in improved quality control as well as in reduced cost of inspection at "Robertshaw".

QUALITY CONTROL IN THE MANUFACTURE OF ROOM AIR CONDITIONERS, F. E. Dennison, Manager of QC & Inspection, & L. V. Curran, Chief Quality Control Engineer, York Corp., York, Pa.

(Refrigerating Engineering, v. 58, n. 12, Dec. 1950, p. 1174)

This article describes the qua - ity control department in a plant manufacturing air conditioning equipment. The principal function of this group is said to be "to discover new facts about the capabilities of processes, machines, materials, and operators". The article discusses in a general way how the quality control department approaches this function.

CORRELATION

A MODEL TO AID IN TEACHING PARTIAL CORRELATION, Helen M. Walker, Teachers College, Columbia University & Walter N. Durost, Boston University.

(The American Statistician, v. IV, n. 5, Dec. 1950, p. 5)

An interesting device to aid in the visualization of a three way distribution of frequency. Various partial correlations are illustrated, e.g., height vs weight of children with age held constant and height vs age for uniform weight. Regression lines and planes can be illustrated.

ENGINEERING & EXPERIMENTS

THE INFLUENCE OF "STATISTICAL METHODS FOR RESEARCH WORKERS" ON THE DEVELOPMENT OF THE SCIENCE OF STATISTICS, F. Yates, Rothamsted Experimental Station.

THE IMPACT OF R. A. FISHER ON STATISTICS, Harold Hotelling, University of North Carolina.

THE FISHERIAN REVOLUTION IN METHODS OF EXPERIMENTATION, W. J. Youden, National Bureau of Standards.

R. A. FISHER'S "STATISTICAL METHODS FOR RESEARCH WORKERS", Kenneth Mather, University of Birmingham.

(Journal of the American Statistical Association, v. 46, n. 253, March 1951, p. 19-35-47-51)

This series of articles is in commemoration of the 25th anniversary of the publication of R. A. Fisher's important contribution.

The first article reviews R. A. Fisher's book "Statistical Methods for Research Workers" and discusses some of the statistical methods that have become important since this book was published 25 years ago. The following are discussed:

Distributions
Chi square (Goodness of Fit)
Correlation
Analysis of Variance
Design of Experiments

A history of the distribution of the book through its 11th Edition in 1951 is given.

The second paper in honor of the silver anniversary year of R. A. Fisher's book, reviews the effects of this work upon the field of statistics in general.

Next Mr. Youden discusses the immediate effect of the book and the changes thereby effected.

Mr. Mather discusses Fisher's original works and others that followed it. A comparison of these works and their effects is given.

MANAGEMENT & PERSONNEL

HUMAN ASPECTS OF ENGINEERING QUALITY INTO A PRODUCT, Carl L. Gartner, Allen B. Dumont Laboratories.

(Part I, TV Engineering, v. 1, n. 12, Dec. 1950, p. 10)

(Part II, TV Engineering, v. 2, n. 1, Jan. 1951, p. 26)

From a paper presented at Syracuse IRE-RTMA meeting.

A discussion of management factors in the success of quality control planning. Necessity for proper controls in all phases of engineering and manufacture is stressed.

AKRON GROUP SYMPOSIUM ON STATISTICAL QUALITY CONTROL. Material is review of panel discussion. Principal speaker—William H. Smith, Ford Motor Co.

(India Rubber World, v. 123, n. 6, March 1951, p. 690)

This article is a review of a panel discussion held at the Akron Rubber Group's fourth annual mid-winter symposium-type meeting at Akron, Ohio, Feb. 2, 1951. Questions and answers are given on problems arising in setting up a quality control program and in making it work to the best advantage.

HOW QUALITY CONTROL BENEFITS FROM GOOD PLANT LAYOUT, R. W. Mallick, Westinghouse Electric Corp. & A. T. Gaudreau, Rimbach & Associates.

(American Machinist, v. 95, n. 3, Feb. 5, 1951, p. 132)

Quality Control as a "permanent institution", particularly in the metal working industries must be provided for and considered in the plant layout. Arrangements should be made so that the function of quality control can be automatically executed as an integral part of the process.

This article discusses many of the factors that must be considered in the plant layout to accomplish this goal.

MISCELLANEOUS

BETTER PRODUCT AT LOWER COST WITH STATISTICAL QUALIY CONTROL. (A "Camera Tour")

(Factory Management & Maintenance, v. 109, n. 3, March 1951, p. 88)

Some 16 photographs outlining the Quality Control organization and methods of Telechron, Inc.

SEQUENTIAL SAMPLING

SEQUENTIAL SAMPLING SIMPLIFIES RECEIVING INSPECTION, Gilbert C. Close.

(Modern Machine Shop, v. 23, n. 11, April 1951, p. 132)

An elementary presentation of the mechanics of Sequential Sampling applied to receiving inspection. Several tables are given.

THEORY & APPLICATION—GENERAL

STATISTICAL AIDS FOR TOOL ENGINEERING, Laurence E. Doyle, University of Illinois.

Part I: INTRODUCTION TO THE ELEMENTS OF STATISTICS

(Tool Engineer, v. XXV, n. 6, Dec. 1950, p. 17)

Part II: PROBABILITY AND THE ACCUMULATION OF TOLERANCES

(Tool Engineer, v. XXVI, n. 1, Jan. 1951, p. 38)

Part IIa (Tool Engineer, v. XXVI, n. 2, Feb. 1951, p. 46)

Part III: MEASURING THE DISTRIBUTION OF ERRORS

(Tool Engineer, v. XXVI, n. 3, March 1951, p. 55)

Part IV: STATISTICAL ANSWERS TO TOOL ENGINEERING PROBLEMS

(Tool Engineer, v. XXVI, n. 4, April 1951, p. 42)

Part IVa—Conclusion (Tool Engineer, v. XXVI, n. 5, May 1951, p. 46)

In Part I Mr. Doyle discusses the basic concepts of probability and their significance. The use of probability theorems used to find the probability of a specific occurrence is illustrated. Frequency distributions and the statistics thereof are next presented in a semi-technical, general interest manner.

Part II and IIa discuss the problems of the resulting tolerances due to the combination of parts with their various individual tolerances. The effects of the distributions of the parts upon the combination tolerance are considered. Formulae for the combinations of tolerances from various types of parent distributions are developed.

The causes of variation within a distribution are outlined in Part III. The control chart concept and the basic development of several constants (A_1 A_2 c_2 D_3 and D_4) is briefly given.

Part IV contains such other use of statistics in tool engineering as:

1. Discovering and correcting the causes of errors.
2. Finding the practical manufacturing limits for a dimension as a basis for setting tolerances.
3. Determining whether a method or operation is likely to meet the specifications for which it is proposed.
4. Finding the limits to which machines and tools can be expected to work.
5. Estimating the effect of tool wear.

The first of these is discussed in this section.

Part IVa continues the discussion of these points with emphasis on the effects and control of tool wear.

TRAINING AND EDUCATIONAL

THE DEVELOPMENT OF STATISTICAL QUALITY CONTROL IN UNITED STATES. S. B. Littauer.

(The American Statistician, v. IV, n. 5, Dec. 1950, p. 14)

The history of Quality Control is divided into 4 main periods:

1. Prior to 1924
2. 1st five years (contributions of Shewhart and associates)
3. Extension and development, 1929-1945
4. Present and future—1945 on.

Each of these periods is discussed in terms of the people, events and achievements that made up the era. The chronological sequence of modern quality control development is given in some detail. Included are references to books, sampling plans, reports and activities that make up this history.

STATISTICS

ESTIMATING THE MEAN AND VARIANCE OF NORMAL POPULATIONS FROM SINGLY TRUNCATED AND DOUBLY TRUNCATED SAMPLES. A. C. Cohen, Jr., The University of Georgia.

(The Annals of Math. Stat., v. 21, n. 4, Dec. 1950, p. 557)

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AMERICAN SOCIETY NEWS

NOMINATIONS FOR A 1951 SHEWHART MEDALIST

It is not too early to begin considerations for a candidate to be chosen as the next Shewhart Medalist of ASQC. The award is made for outstanding leadership in the field of modern quality control. Responsibility for selecting a medalist rests with the Shewhart Medal Committee, subject to approval by the Executive Committee of the candidate chosen.

As a democratic, professional society, nominations for this award are invited both from individual members and from local Sections of ASQC. The Shewhart Medal Committee welcomes such assistance and interest and urges you to place before it the name of your candidate *now*. Submit your nomination to the Chairman of the Shewhart Medal Committee—

Warren R. Purcell
Brown Company
Berlin, New Hampshire

NOMINATIONS FOR THE 1951 BRUMBAUGH AWARD

The Brumbaugh Award represents another way in which ASQC seeks to honor outstanding service to the Society. It is made each year to the author of the paper published in Industrial Quality Control that has been judged by the Brumbaugh Award Committee to have made "the greatest contribution to the development of industrial applications of quality control".

This committee must of necessity depend heavily on a response from readers of our journal to assist it in recognizing that paper which has best met the criterion on which the award is based. Members of ASQC are therefore earnestly urged to assist the Brumbaugh Award Committee by sending in nominations for the next award. The 1951 award will be limited to authors whose papers were published in Volume VII (July 1950—May 1951 inclusive). Send your nomination *now* to the Chairman of the Brumbaugh Award Committee—

Halsey H. Kent
Eastman Kodak Co.
Camera Works
333 State Street
Rochester 4, New York

EDITORIAL BOARD

According to the plan recommended by the Editorial Board and approved by the Executive Committee, membership on that Board shall now be of a rotating nature. Members will serve a term of five years with three members retiring each year. A plan of retirement was worked out by the Board and on June 30, 1951, the retiring members were Irving W. Burr, Churchill Eisenhart, and William B. Rice. Retiring members are not eligible for reappointment until after a lapse of one year.

The Society owes a great debt of gratitude to these three members. The leadership and guidance of these men, the keen analysis of the problems of our Society and its use in shaping the character of our magazine, are matters seldom understood and but rarely appreciated. They have contributed generously of their time, and their part in helping to build a magazine of which the Society is justly proud should be a source of considerable satisfaction to them. The Society, herewith, expresses its sincere appreciation to these retiring members of the Editorial Board.

The Society, and its Editorial Board, is pleased to be able to announce the following capable replacements for the above:

Warren R. Purcell, Brown Company, Berlin, New Hampshire

Harry G. Romig, Hughes Aircraft Company, Culver City, California

John W. Tukey, Princeton University, Princeton, New Jersey

These men have agreed to serve a five year term ending June 30, 1956, and it is with the greatest of confidence that we add them to the Board. The qualifications of these men are so well known that they require no further elaboration and we are indeed fortunate to be able to count on their valuable assistance.

AUTOMOTIVE TECHNICAL COMMITTEE

Effective July 1, 1951, the Chairmanship of this important Committee will be assumed by Mr. Nelson G. Meagley, Manager of Statistical Quality Control, Willys-Overland Motors, Inc., Toledo, Ohio. All members who are interested in actively working on this Committee are invited to contact its Chairman.

CORRECTION

In the paper "Quality Control at Talon, Incorporated" appearing in the March, 1951 issue of IQC the name of one of the joint authors was incorrectly spelled. The correct spelling should be J. Stuart Zahniser. Sincere apologies are extended to Mr. Zahniser for this regrettable error.

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

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TESTING ENGINEER—Available for part time Quality Control position, nights and weekends in Cleveland-Canton, Ohio area. Fifteen years industrial experience in testing and research; ASTM work, publications; M. S. degree. Desires opportunity to expand present knowledge of Quality Control. Write to 8A2 American Society for Quality Control, Room 5036, 70 East 45th Street, New York 17, N. Y.

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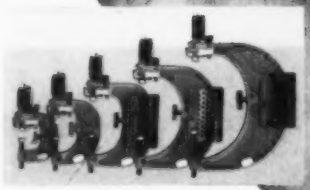

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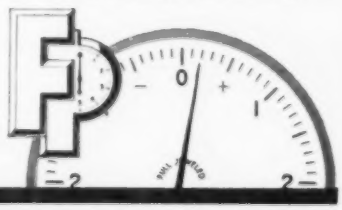
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